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Journal

—OF THE—

American Ceramic Society

A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries

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JOURNAL
OF THE
AMERICAN CERAMIC SOCIETY

A monthly journal devoted to the arts and sciences related to the silicate industries.

Vol. 3 **December, 1920** **No. 12**

EDITORIAL

THE ANNUAL MEETING

As noted in the November issue, the 1921 annual meeting of the Society will be held on February 21, 22, 23, 24, at Columbus, Ohio. The new and commodious Hotel Deshear has been engaged as headquarters.

The Committee on Papers and Programs is planning to make this meeting the most interesting and valuable, from the standpoint of ceramic technology, in the history of the Society. There will be a complete session devoted to the firing of kilns, which will cover all the different phases and types. There will also be a session devoted to the discussion of sagger problem. This is a very live topic and should prove interesting to all users of saggers. A large number of interesting papers suitable for presentation at the general sessions have been promised. In addition, arrangements are being made for the presentation of excellent programs at the meetings of each of the various Divisions.

Details of the social entertainment are in the hands of the local committee, of which Professor A. S. Watts is chairman, and it is expected that the usual Section Q, or smoker, will take place on Monday night, with the banquet on Tuesday. Those who recall these delightful events at the Philadelphia meeting will not fail to be present this year. Members are urged to bring their wives to the meeting, since special arrangements are being made to entertain a large number of ladies. The trips to be taken on the last day of the meeting will be replete with in-

terest, as Columbus is situated at the very heart of the clay-working industry.

The Collective Index

The Collective Index to the Transactions of the American Ceramic Society is ready for distribution. This will be welcome news to those who own and use the volumes, since it will increase the value of the volumes very much.

The Index has been compiled by men experienced in the kind of work involved, and careful cross-references make it possible to find subjects wherever they are mentioned or discussed. There are two parts to the book, the first a classification by authors, the second by subjects. In all there are over 7000 entries.

Bound to match the green cloth copies of the Transactions, the Index will be an important and attractive addition to both private and public libraries.

Readjustment of Dues and Fees

In former years, an Associate member was charged five dollars initiation fee and five dollars dues for each year, including the first. When he was promoted to Active membership he was charged a second initiation fee of ten dollars. Thus, the yearly average amount paid by a member in the Associate grade depended on the length of time he remained in that grade. In the case of men who were especially zealous in the work of the Society and, therefore, were quickly elevated to Active membership, it ran as high as ten, twelve and a half and even twenty-five dollars. The more dilatory members paid a much lower average fee.

On February 1st of this year the initiation fee paid by Associates upon promotion to Active membership was abolished. Beginning January 1, 1921, the initiation fee for entrance into the Associate grade will be discontinued also. At the same time, the annual dues of Associate members will be raised to seven dollars and fifty cents. The average amount received from a member will be about the same as in former years, but inequality of payment by various members will be overcome. Another advantage will be that Associate and Active members will pay the same amount, and promotion to Active membership will not be accompanied by a fee for the honor conferred.

ORIGINAL PAPERS AND DISCUSSIONS

CLAY STORAGE WITHIN THE FACTORY

By T. W. Garve

A raw clay storage building is not a necessity for a clay working plant, yet "the clay storage within the factory" is essential and modern plants are not built without such.

To insure continuity of operation it is necessary to have a supply of crushed and ground shale or clay on hand to bridge over breaks and delays and to keep the machinery running ahead of the bin. It is well for the superintendent, and for the men, to know in the morning that there is enough clay supply on hand within the factory to see the day through for production. Besides, any further handling and storing of clays will improve the quality of the clay by intermixing of the particles and their exposure to air.

Bins employed for such purposes are usually built overhead. This will put the storage out of the way, and allow for passage below and for the installation of feeders at the bottom for continuous and automatic feed to the grinding or pugging machinery.

For delivering raw shale or dry lumpy clay to the factory it is well to dump the contents of the car into a pocket at the bottom of which a plate feeder is operating to insure a steady uniform charge of material to the crusher (or dry pan).

If a crusher is used ahead of the dry pan it is proper to place a storage bin between them for keeping crushed material on hand. The crushed material can be fed out of such a bin by means of a reciprocating plate feeder as before or by a disc feeder. The ground material should be stored again above the pug mill with a disc feeder to permit of fine adjustments.

The amount of water required for pugging can also be regulated here close to the feeder. To insure uniformity in the water pressure, a tank can be set up above the mill and the water be piped down. Some plants have worked out a scheme of using two valves in this pipe line, one for maximum opening and complete closing and one valve ahead of it for final adjustments; or a

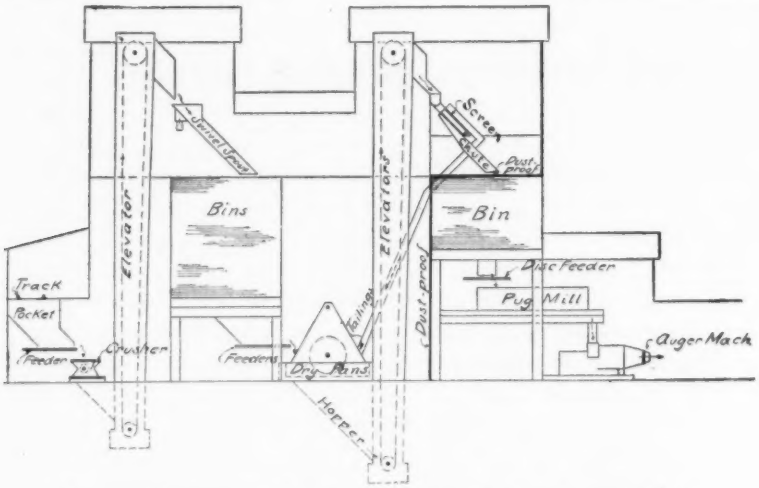


FIG. 1.—Arrangement for storing crushed shale and ground shale.

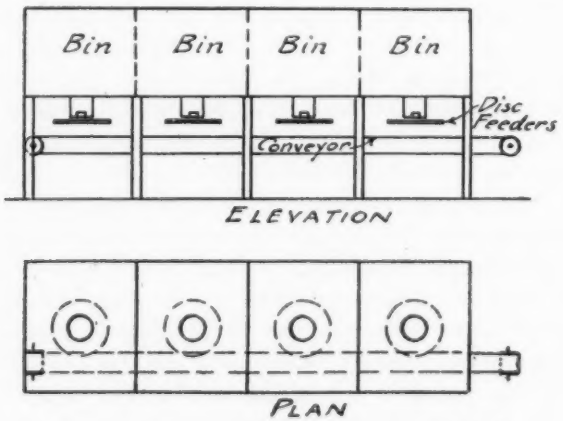
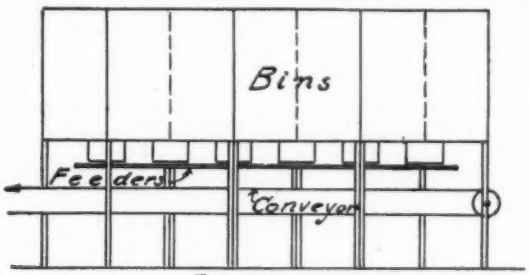
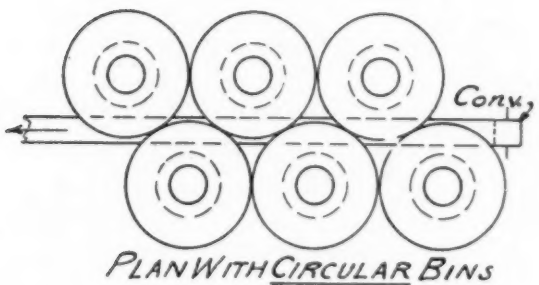


FIG. 2.—Arrangement for storing and mixing.

so-called "poidometer" can be used which weighs and regulates the amount of clay and water delivered to the pug mill.

Storage bins may be circular or rectangular. A circular bin can be built of steel plates as a cylinder set on a properly con-





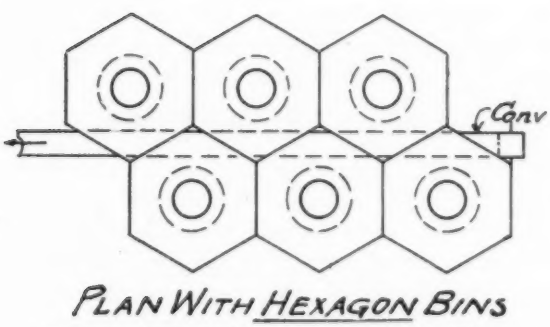


FIG. 3 — Arrangements for storing and mixing.

tructed platform or floor, or a standard galvanized steel tank can be used with a hole cut into its bottom for the passage of the clay to the cylinder of the feeder. Circular bins can also be built like water tanks of wooden staves and iron hoops.

Square or rectangular bins require more material for their construction than circular bins but they often fit better into their surroundings and can be made part of the building. They can be framed and sheathed structures, or cribbed plank laid flat and spiked together. Frame bins should be properly tied with tie rods both ways to prevent their distortion and bulging.

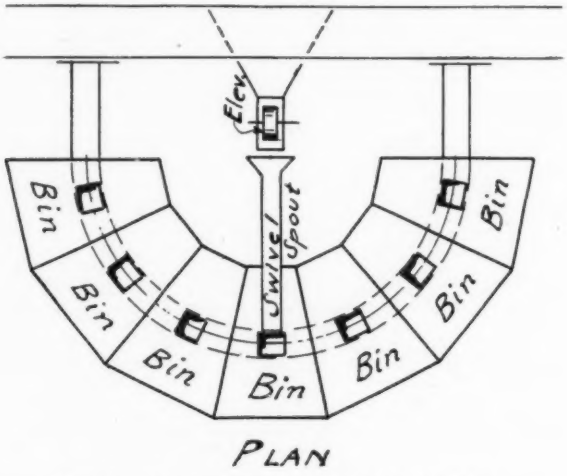


FIG. 4.—Arrangement for storing and mixing.

Circular as well as square bins can also be built of reinforced concrete, or posts and floors can be built of reinforced concrete and an independent frame or steel bin set on top of it.

Examples of Dry Clay Storage

In figure 1 we have a typical arrangement for a brick or tile plant. There is a pocket for the raw material and storage provisions for the crushed shale as well as for the ground shale.

Where a number of different clays are to be used, as in the manufacture of fire-bricks or refractories or pottery, a corresponding number of bins will have to be built, and they can be

arranged in a single row or double row or in a semi-circle depending upon the layout of the plant and the number and size of bins, as seen in the following sketches.

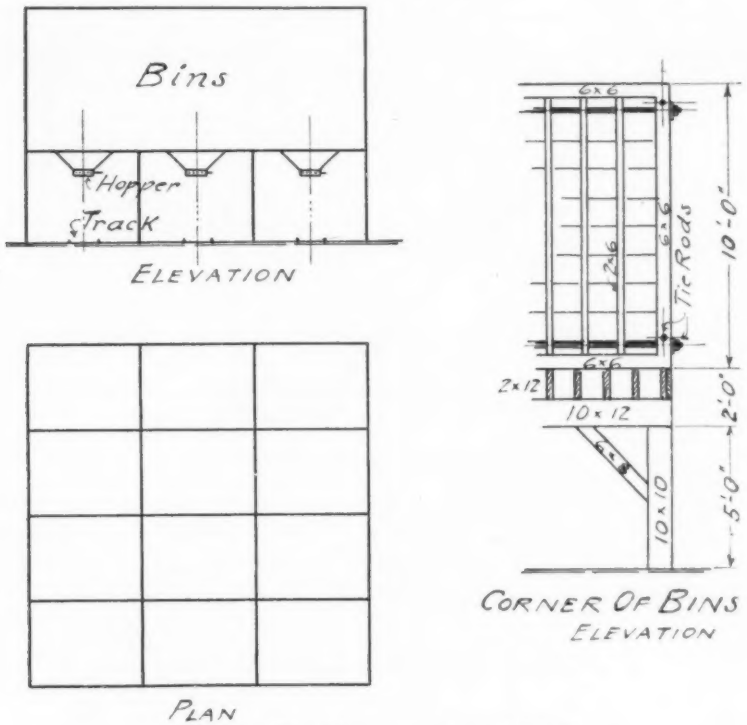


FIG. 5.—Clay bins, assembly and detail.

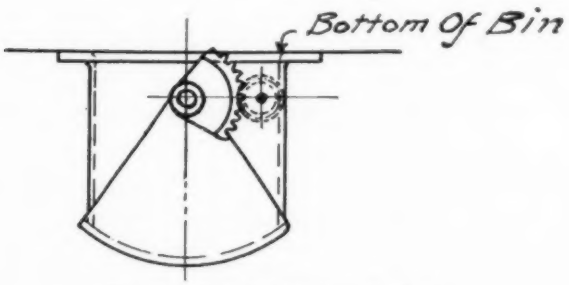


FIG. 6.—Gate for bottom discharge.

In figure 2 we have one row of bins with a disc feeder at the bottom of each bin for supplying the proper quantity of clay to the mixture on the belt.

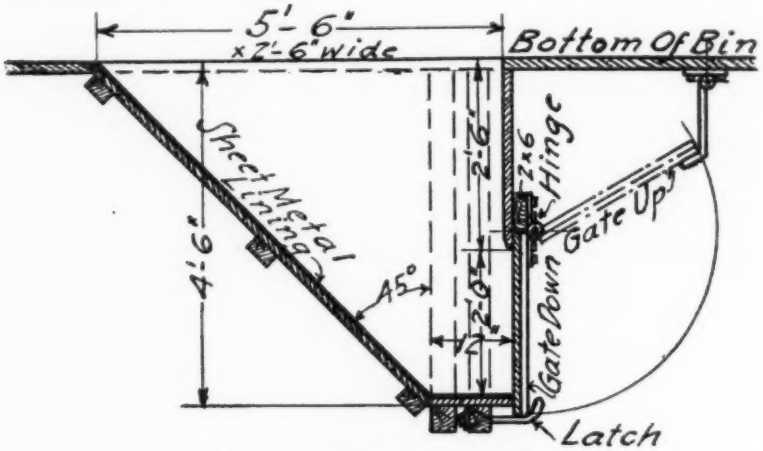


FIG. 7.—Bottom discharge of bin.

In figure 3 there are two rows of bins being charged from a car of the side dump type. Such bins can be square or circular or hexagon. Hexagon bins will utilize the space to greater advantage than circular bins and will reach farther over the conveyor.

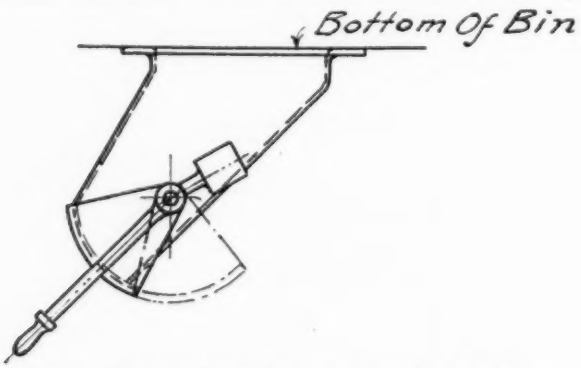


FIG. 8.—Under-cut gate for bottom or side discharge.

Figure 4 shows bins arranged semi-circular around an elevator. The bins can be emptied by feeders as before or by a car (which

can be a measuring car) running on a semi-circular track, to be taken to the pit or pug mill.

In figure 5 we have a larger number of bins arranged in three rows with a track below each. The bins may have a hopper bottom with a slide gate as shown or cast iron outlets may be used as illustrated in figure 6 which are made with either single or double swing-gate. Fine adjustments in the feeding are also

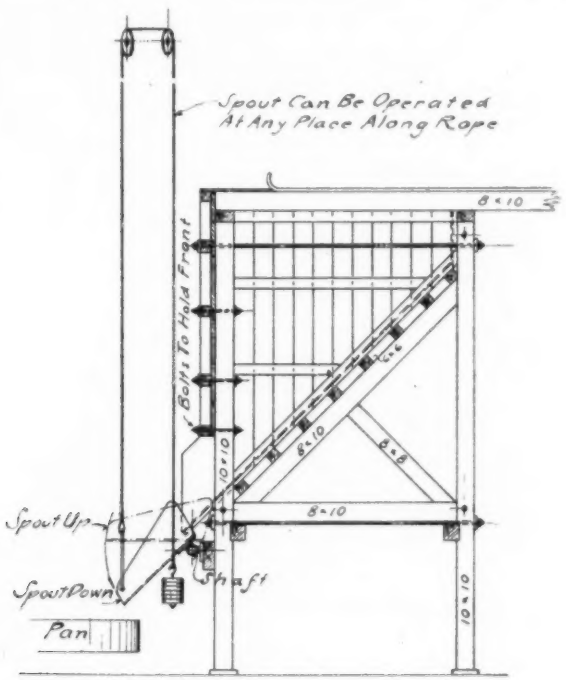


FIG. 9.

accomplished by arrangements as shown in figures 7 and especially 8 which can be used for either bottom discharge or side discharge of bins.

In figure 9 we have an illustration of a bin with an inclined bottom and a side discharge. Such a bin will hold less clay than one with a flat bottom. An inclined bottom will insure a more uniform sliding, while a flat bottom on the other hand will give

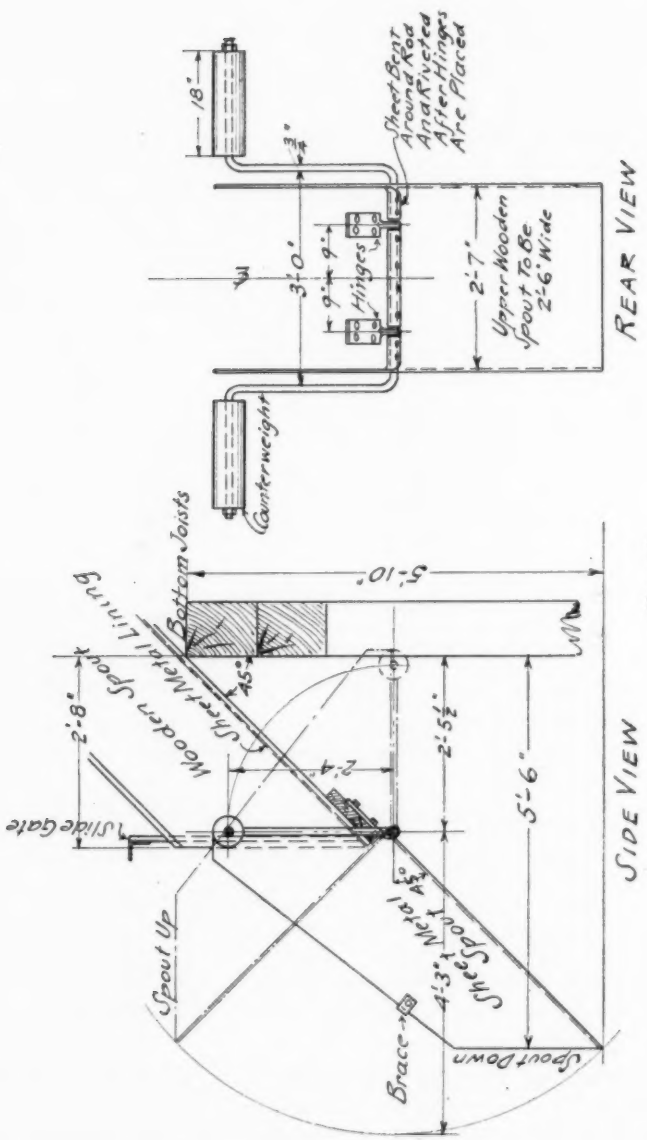

Sheet Iron Around Rod and Riveted After Hinges Are Placed
18"
3/4"
3'-0"
9"
9"
Hinges
2'-7"
Upper Wooden Spout To Be 2'-6" Wide
REAR VIEW
Counterweight
Bottom Joists
5'-10"
Guiding Metal Limits
45°
Upper Metal Spout
Wooden Spout
2'-8"
2'-4"
2'-5½"
5'-6"
Slide Gate
Spout Up
Metal Spout
4'-3"
Brace
Spout Down
SIDE VIEW

FIG. 10.

additional storage at the corners which can be shoveled out or scraped down in an emergency, should the supply run low. This statement holds good for crushed but not always for finely ground material since some shales which are slightly moist or oily will be

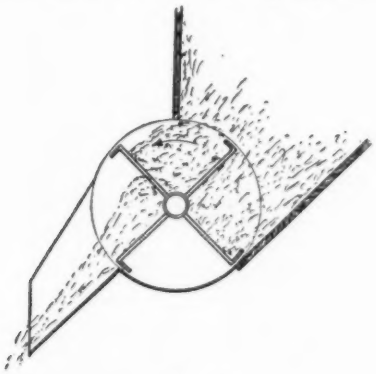


FIG. 11.

packed down by the weight above and the unavoidable, though slight vibrations of the bin structure so that the material from the corners would have to be broken loose and be crushed again. The flow of clay is stopped by merely raising the front spout high

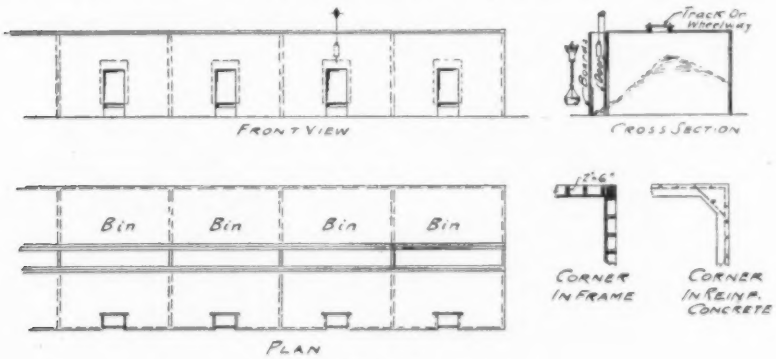


FIG. 12.

enough. Another similar spout, but with an additional slide gate behind for shutting off the supply or for regulating it, is shown in figure 10. Both these gates are counterbalanced.

We have deemed it advisable to go into some details of construction and supply dimensions on the drawings since a good deal of such equipment could be made up in the factory in a manner as shown or any similar manner to suit the requirements.

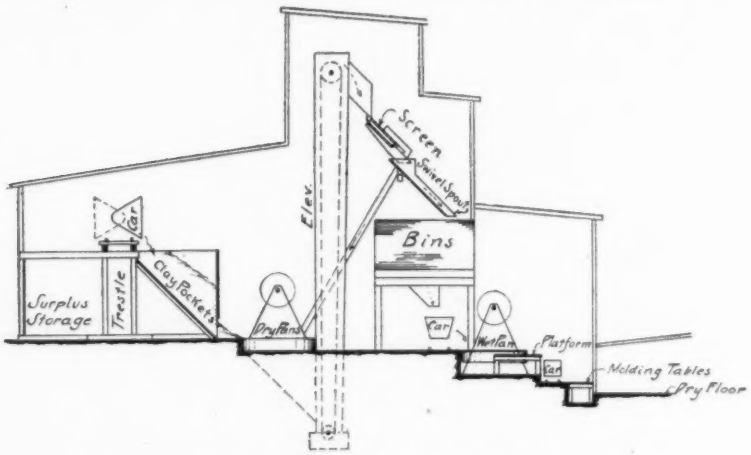


FIG. 13.—Storage in a refractory plant.

In figure 11 we have shown a rotary drum or rotating compartment feeder at the end of a bin spout for feeding a pan or other machinery. By making the drum long enough and introducing side partitions (not shown) we can mix two or three kinds of clay and feed them automatically.

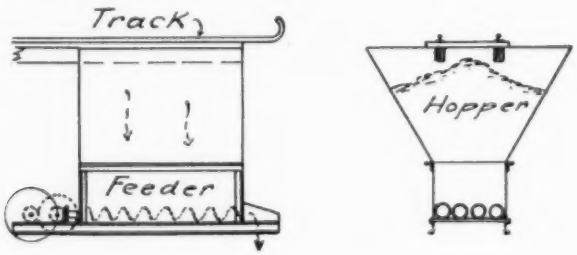


FIG. 14.

In figure 12 we have bins built on the ground or floor, filled from above, intended for fire clays and grogs as used in the manufacture of special refractories, pottery, saggers, etc., requiring

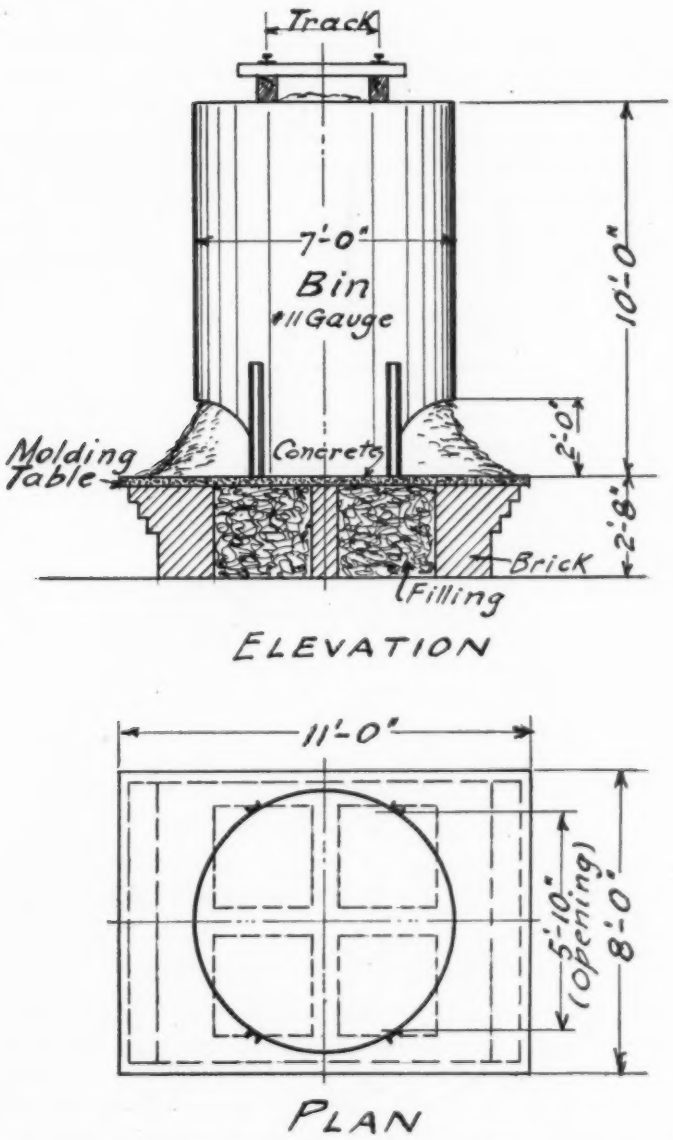


FIG. 15.—Storage above molding table.

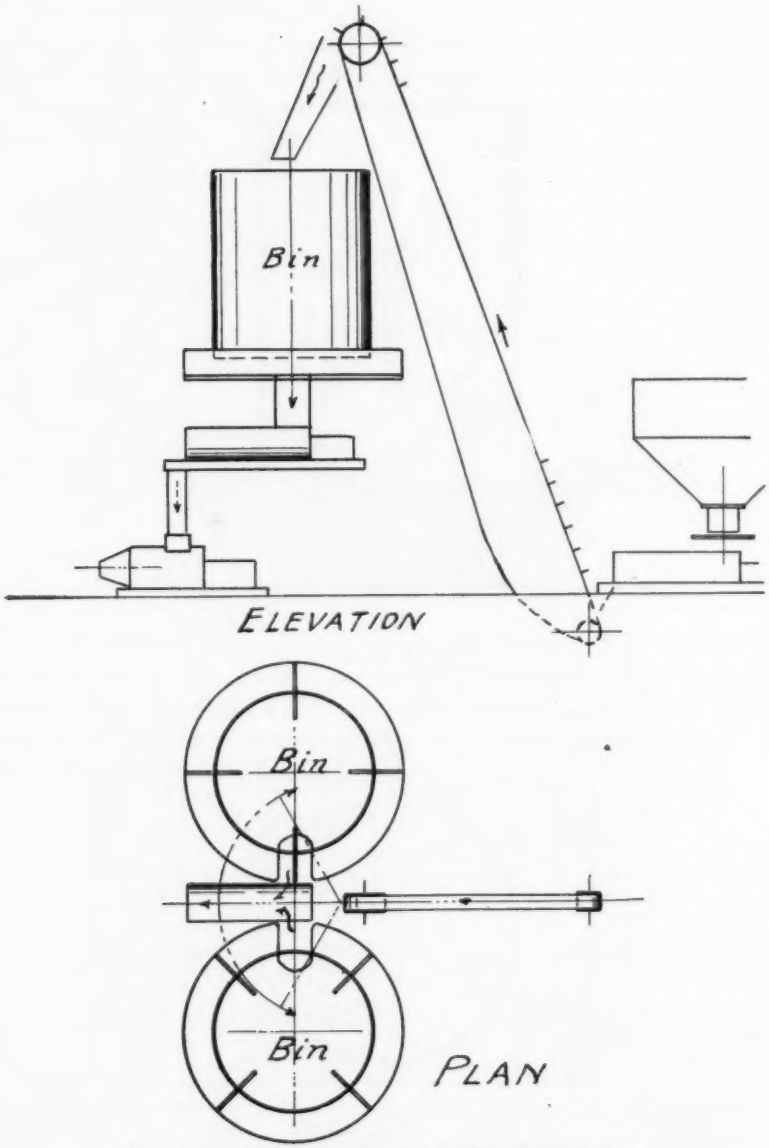


FIG. 16.—Wet clay storage for continuous operation.

a number of clays and variable mixtures. There is a place in front of each bin for scooping up the material and filling it into a wheelbarrow or truck or into a traveling tray of a mono-rail carrier. For large bins, the rail can be extended into the bins. For this system the material can be weighed at each bin by a scale attached to the tray. If shoveled into wheelbarrows the amount is weighed near the scoop of the mixing machine where the batch is made up. Such bins can be built of frame or of reinforced concrete.

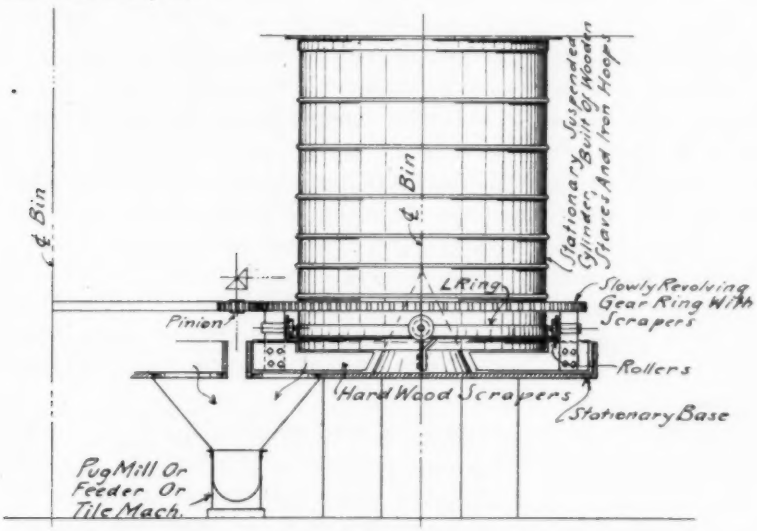


FIG. 17.

Figure 13 shows the arrangement for storing the clays in a small plant for making hand moulded fire-brick and refractories. The drawing explains itself.

Examples of Wet Clay Storage

So far we have been dealing with dry materials but when it comes to the handling and storing of wet clays the problem is more difficult.

While refractory and pottery plants are storing wet clays for the purpose of ageing to improve the working conditions and quality, the storage supply is but a secondary consideration.

Where wet or moist clays are used in the manufacture of brick or tile, they are usually dumped by means of a bottom dump car or by a dumping device into a hopper above a screw feeder as shown in figure 14. There is usually but enough storage provided to last until the return of the car. A screw feeder is adoptable for feeding wet clays where the ordinary disc feeder would not do. If very sticky clays are worked, they would bridge over in a hopper with inclined sides as shown, and it will be necessary here to build the hopper straight.

Figure 15 shows the storage bin for the prepared wet material above the molding table as it is used in silica brick plants.

In figures 16 and 17 finally we have illustrated a suggestion for storing wet clay in a continuous operation for the manufacture of drain tile.

It has been observed that from some shales the first product in the morning, taken from the material which remained in the pug mill over night, does not give the very objectionable ragged ends in the cutting. The duration of one night is evidently sufficient to get all clay particles sufficiently softened to produce the better ware, and it would unquestionably pay in many cases to introduce a wet storage bin without breaking the continuity of the operation.

We have illustrated such an arrangement, in the last two drawings, with two bins and a feeder at the bottom of each. The two bins can be filled and emptied alternately from day to day allowing sufficient storage for each, or both bins can be emptied and filled at the same time. If the capacity of the bins is drawn during the day, the new material, reaching the bottom at the end of the day's run, will remain in the bin over night to be drawn out the next day, and so on. To eliminate the wet clay elevator, the dry material can be elevated to a pug mill above the bins.

While wet pans might accomplish the same, it is obvious that the above system eliminates the great power consumption of wet pans.

2782 N. High Street
Columbus, Ohio

Notice—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

A CLASSIFICATION OF ENAMELS FOR SHEET STEEL*

By R. R. Danielson

An inspection of commercial formulas for sheet steel enamels shows a considerable variation in the chemical composition; in certain instances even in the case of enamels used for the same type of ware. In spite of these permissible variations a study of a large number of commercial formulas shows that there are certain typical classes into which these various compositions can be grouped.

Sheet steel enamels may be classified generally into two rather distinct groups, that is the gray or so called granite ware enamels and the three-coat enamels. In this first group we have a single coat of enamel applied to the metal, and mottled by the formation of rust spots on the metal. This ware is given a single firing when it is finished and ready for the trade. Enamels typical of this group are shown in table 1.

The melted compositions are shown on the same table, it being assumed in computing these that such materials as feldspar, fluorspar and bone ash lose no weight in smelting. Gray enamel A is typical of some of the earlier types of gray ware enamel containing a comparatively high content of quartz in addition to feldspar as a refractory. It contains considerable opacifying agents in the form of fluorspar, bone ash and antimony oxide.

Table 1—Gray Ware Enamels

Raw Batch Composition of Frits

	A	B	C
Feldspar	30.0	40.0	48
Borax	28.5	30.5	40
Quartz	19.0	10.0	...
Soda ash	8.0	6.5	3.0
Sodium nitrate	4.0	5.5	4.0
Fluorspar	3.0	1.5	...
Bone ash	5.0	4.5	3.5
Antimony oxide	2.5	1.5	1.5
Total	100.0	100.0	100.0

Mill Batch: Frit 100.0, clay 6.0, magnesium carbonate 0.25, water 50.0.

* Read at the meeting of the Society at the Chemical Exposition, New York City, Sept. 24, 1920.

Percentage Composition of Melted Frits

	A	B	C
Feldspar	37.2	50.3	62.05
Quartz	23.5	12.6	..
B_2O_3	12.8	14.1	18.9
Na_2O	13.4	13.5	12.6
Fluorspar	3.7	1.9	..
Bone ash	6.3	5.7	4.5
Antimony oxide	3.1	1.9	1.95
Total	100.0	100.0	100.0

TABLE 2—GRAY WARE ENAMELS

Empirical Formulas

A 0.05 K_2O, .77 Na_2O, .18 CaO | 0.103 Al_2O_3, .312 B_2O_3, .019 Sb_2O_3 | 1.39 SiO_2, .079 F_2, .033 P_2O_5

1.00

$\frac{SiO_2}{B_2O_3} = 4.46$ $\frac{SiO_2}{Al_2O_3} = 13.5$

B 0.116 K_2O, .676 Na_2O, .208 CaO | 0.228 Al_2O_3, .545 B_2O_3, .017 Sb_2O_3 | 2.18 SiO_2, .065 F_2, .048 P_2O_5

1.000

$\frac{SiO_2}{B_2O_3} = 4.0$ $\frac{SiO_2}{Al_2O_3} = 9.56$

C 0.153 K_2O, .721 Na_2O, .126 CaO | 0.310 Al_2O_3, .805 B_2O_3, .019 Sb_2O_3 | 2.18 SiO_2, .042 P_2O_5

1.000

$\frac{SiO_2}{B_2O_3} = 2.7$ $\frac{SiO_2}{Al_2O_3} = 7.03$

Gray ware enamel B is a type showing the tendency to reduce the amount of quartz and replace it with feldspar. There is apparent a desire to reduce the amount of antimony oxide and of fluorspar, and we note a slight increase in the content of boric

oxide, probably to retain a fusing temperature similar to that of enamel A.

Gray enamel C is a type much in use at the present time. Quartz has been eliminated entirely and has been replaced by feldspar which remains as the sole refractory. Fluorspar has been eliminated and the boric acid increased to care for the decrease of other fluxes. It is to be noted in the three types that the content of sodium oxide remains fairly constant, and this is undoubtedly due to the fact that higher amounts of sodium oxide give difficulties from blistering and boiling. The next change in this class of enamels will probably be in the elimination of antimony oxide and its replacement by some opacifying agent to which there is not attached the prejudice now associated with antimony.

The usual mill additions to the gray ware frits consist of about six per cent of some high grade ball clay, one-fourth of one per cent of magnesium carbonate and about one-fourth of one per cent of some electrolyte, such as magnesium sulphate or cobalt and nickel sulphates. These sulphates play a part in tempering the enamel to such a viscosity that it may be properly applied to the steel and also promote rusting of the metal, which gives rise to the mottled granite appearance. Certain plants make use of small amounts of metallic oxides to produce various shades of gray, but the amounts added are usually so small that they do not play any material part in the behavior of the enamel. These oxides are added to the raw enamel batch previous to smelting and may consist of 0.01 to 0.02 per cent of cobalt oxide and 0.2 to 0.3 per cent of nickel, manganese or iron oxides.

The empirical formulas for these three gray ware enamels have been calculated and are shown in table 2. It has been assumed for these and subsequent calculations that all the materials entering into the enamels have approached the theoretical compositions, which is true of most enamel ingredients except that of feldspar. For this we have assumed the composition of an average Connecticut feldspar with the following percentage composition: 71 SiO_2, 17 Al_2O_3, 8 K_2O and 4 Na_2O. A study of these empirical formulas shows a slight decrease in the refractoriness, due principally to a decrease in the silica-boric oxide ratio.

TABLE 3—GROUND COATS

Raw Batch Composition of Frits

	A	B	C
Borax	30.0	30.0	39.5
Feldspar	22.0	27.0	20.5
Quartz	29.0	20.5	22.5
Soda ash	5.0	9.8	5.0
Soda nitre	4.6	5.0	4.7
Fluorspar	6.0	6.0	6.0
Cobalt oxide	0.4	0.5	0.4
Manganese oxide	2.0	1.2	1.0
Nickel oxide	1.0	...	0.4
Total	100.0	100.0	100.0

Mill Batch: Frit 100.0, clay 7.0, borax 1.5, water 50.

Percentage Composition of Melted Frits

	A	B	C
Feldspar	27.2	34.3	26.9
Quartz	36.0	26.2	29.6
B_2O_3	13.6	14.0	18.9
Na_2O	11.6	15.8	14.4
CaF_2	7.4	7.6	7.9
CoO	0.5	0.63	0.5
MnO	2.47	1.5	1.3
NiO	1.23	..	0.5
Total	100.0	100.0	100.0

TABLE 4—GROUND COATS

Empirical Formulas

$$A\ \left\{\begin{array}{l} 0.5490\ Na_2O \\ .0615\ K_2O \\ .2530\ CaO \\ .0164\ CoO \\ .0757\ MnO \\ .0444\ NiO \\ \hline 1.0000 \end{array}\right\} \left\{\begin{array}{l} 0.1203\ Al_2O_3 \\ .5175\ B_2O_3 \end{array}\right\} \left\{\begin{array}{l} 2.445\ SiO_2 \\ .2530\ F_2 \end{array}\right.$$

$$\frac{SiO_2}{B_2O_3} = 4.73 \qquad \frac{SiO_2}{Al_2O_3} = 20.3$$

B	0.6399 Na_2O	0.1322 Al_2O_3	1.9200 SiO_2
	.0673 K_2O	.4620 B_2O_3	.2260 F_2
	.2260 CaO		
	.0182 CoO		
	.0486 MnO		
	1.0000		

$$\frac{SiO_2}{B_2O_3} = 4.16 \qquad \frac{SiO_2}{Al_2O_3} = 14.5$$

C	0.6222 Na_2O	0.1120 Al_2O_3	2.008 SiO_2
	.0558 K_2O	.6710 B_2O_3	.2502 F_2
	.2502 CaO		
	.0162 CoO		
	.0374 MnO		
	.0182 NiO		
	1.0000		

$$\frac{SiO_2}{B_2O_3} = 3.0 \qquad \frac{SiO_2}{Al_2O_3} = 17.9$$

Three coat enameled ware, as its name indicates, is coated with three coats, a ground and two cover enamels. The following compositions given in table 3 are typical of ground coats in American practice. They may be grouped according to the type of ware to which they are applied as well as upon their refractoriness.

Ground A is a refractory enamel because of its high content of quartz and low amount of fluxes and for that reason is not adapted to lighter gauge shaped ware or to flat ware, such as signs and stove work, which would tend to buckle in the comparatively high temperature required for its fusion. It is used with success on heavy gauges of shaped ware such as enameled pipe, pails and containers. Because of its high content of metallic oxides, it is a tough durable enamel giving excellent service on ware subjected to hard service.

Ground B is one in use for flat ware such as stove work, table tops and two or three color signs and for medium gauge shaped ware. It is a high sodium oxide enamel with a medium content of refractories and is fired at a medium temperature.

Ground C is a type which has been used on light gauge drawn and spun ware. Because of its high boric oxide content it is not

desirable for the manufacture of flat ware where there is an opportunity for free expansion and contraction of the metal. It has a low fusion temperature, because of its low content of refractories and increased content of fluxes.

The empirical formulas are shown in table 4 and the silica-boric oxide ratios show the increase in boric oxide content.

Cover Enamels

Cover enamels for ordinary three coat ware may be classified in two general groups, as white and colored enamels. The main distinction between these groups is in the content of opacifying agents. The compositions under white enamels shown in table 5 are typical of those which have been used with success and indicate a gradual evolution from the original.

White Enamel A is similar to German enamels in which the feldspar is low and the antimony oxide high. Very often this type is made up with small additions of clay in the raw batch, which would tend to overcome the effect of small amounts of feldspar

White Enamel B shows an increase in the feldspar content and a decrease in the antimony oxide with the same content of fluorspar and cryolite. The increase in feldspar is compensated for by a decrease in the quartz content.

White Enamel C is a type which is used considerably where a very opaque enamel is demanded. It is the most refractory enamel of the three, carrying increased refractories and a smaller content of borax. This decrease in borax is taken care of by the replacement of fluorspar by cryolite, which exerts a greater fluxing action. Empirical formulas for the white enamels are shown on table 6.

The usual mill additions for these types consist of six per cent of a high grade ball clay or some plastic kaolin, seven per cent of tin oxide and 0.5 per cent of magnesium carbonate which aids in the flotation of the prepared enamels.

Colored Enamels

Colored enamels differ from white enamels in that they are usually low in opacifying agents and hence have taken the name of glass or glass frit. Two types are shown in table 7.

Glass A is one which works well for dark colors because of its small content of opacifying agents. Glass B with its high content of opacifiers serves well for light colored enamels as it tends to mask the dark underlying ground coat. A comparison of glasses A and B shows that the main difference is in the decrease of feldspar and increase of fluorspar and cryolite.

Blue and black enamels are made by adding metallic oxides to the raw batch previous to smelting, while the others are produced by milling some oxide or color stain with the frit in the mills. This is done simply because of the intense coloring effect of cobalt which requires the intimate mixture with the other ingredients that is obtained on smelting.

TABLE 5—WHITE COVER ENAMELS

Raw Batch Composition of Frits

	A	B	C
Borax	28.0	27.0	21.0
Feldspar	25.0	31.0	31.0
Quartz	19.0	17.0	22.0
Soda ash	3.5	3.5	3.5
Sodium nitrate	3.5	3.5	3.5
Fluorspar	5.0	5.0	...
Cryolite	12.0	12.0	17.0
Antimony oxide	4.0	1.0	2.0
Total	100.0	100.0	100.0

Mill Batch: Frit 100.0, clay 6.0, tin oxide 7.0, magnesium carbonate 0.5, water 60.0.

Percentages Composition of Melted Frits

	A	B	C
Feldspar	30.1	37.0	35.8
Quartz	23.0	20.5	25.5
B_2O_3	12.3	11.8	8.9
Na_2O	9.4	9.2	7.8
CaF_2	6.0	6.0	...
Cryolite	14.4	14.3	19.7
Antimony oxide	4.8	1.2	2.3
Total	100.0	100.0	100.0

TABLE 6—WHITE COVER ENAMELS

Empirical Formulas

A	0.067 K_2O	0.226 Al_2O_3	1.95 SiO_2
	.730 Na_2O	.458 B_2O_3	.741 F_2
	.203 CaO	.044 Sb_2O_3	
	1.000		

$$\frac{SiO_2}{B_2O_3} = 4.27 \qquad \frac{SiO_2}{Al_2O_3} = 8.64$$

B	0.084 K_2O	0.252 Al_2O_3	2.03 SiO_2
	.716 Na_2O	.448 B_2O_3	.735 F_2
	.200 CaO	.011 Sb_2O_3	
	1.000		

$$\frac{SiO_2}{B_2O_3} = 4.53 \qquad \frac{SiO_2}{Al_2O_3} = 8.06$$

C	0.098 K_2O	0.337 Al_2O_3	2.66 SiO_2
	.902 Na_2O	.398 B_2O_3	.880 F_2
		.025 Sb_2O_3	
	1.000		

$$\frac{SiO_2}{B_2O_3} = 6.68 \qquad \frac{SiO_2}{Al_2O_3} = 7.90$$

TABLE 7—GLASS FRITS FOR COLORED ENAMELS

Raw Batch Composition of Frits

	A	B
Borax	29.0	29.0
Feldspar	24.0	14.0
Quartz	30.0	28.0
Soda ash	10.0	10.0
Sodium nitrate	3.0	5.0
Fluorspar	...	7.0
Cryolite	4.0	7.0
Total	100.0	100.0

Mill Batch: Frit 100.0, clay 6.0, magnesium carbonate 0.5, water 50.0, additions of necessary stains or oxides.

Percentage Composition of Melted Frits

	A	B
Feldspar	30.0	17.75
Quartz	37.4	35.25
B_2O_3	13.15	13.7
Na_2O	14.45	15.7
Fluorspar	..	8.8
Cryolite	5.0	8.8
Total	100.0	100.0

TABLE 8—GLASS FRITS FOR COLORS

Empirical Formulas

$$A\ \left.\begin{matrix} 0.917\ Na_2O \\ .083\ K_2O \\ \hline 1.000 \end{matrix}\right\} \left\{\begin{matrix} 0.202\ Al_2O_3 \\ .615\ B_2O_3 \end{matrix}\right\} \left\{\begin{matrix} 3.17\ SiO_2 \\ .23\ F_2 \end{matrix}\right.$$

$$\frac{SiO_2}{B_2O_3} = 5.15 \qquad \frac{SiO_2}{Al_2O_3} = 15.7$$

$$B\ \left.\begin{matrix} 0.717\ Na_2O \\ .033\ K_2O \\ .250\ CaO \\ \hline 1.000 \end{matrix}\right\} \left\{\begin{matrix} 0.111\ Al_2O_3 \\ .421\ B_2O_3 \end{matrix}\right\} \left\{\begin{matrix} 1.75\ SiO_2 \\ .532\ F_2 \end{matrix}\right.$$

$$\frac{SiO_2}{B_2O_3} = 4.17 \qquad \frac{SiO_2}{Al_2O_3} = 15.8$$

The following figures will give some idea of the methods of obtaining various colors:

Blue: Glass A plus 4 per cent black cobalt oxide and 2 per cent manganese dioxide in raw batch.

Black: Glass A plus 1.5 per cent cobalt oxide, 3.0 per cent manganese oxide, 1 per cent chromium oxide, 0.5 per cent copper oxide and 1.5 per cent iron oxide in raw batch.

The following colors may be produced by additions of oxides or stains to Glass A or B in the mill:

Yellow: 3 to 5 per cent cadmium sulphide.

Green: 3 to 5 per cent chromium oxide.

Other colors may be produced by the addition of from one to five per cent of stain, which may be procured on the market.

Since these stains can not be prepared successfully on a small scale in the individual plants, the various shades of colors can be best produced by the use of these prepared stains.

Summary

In this paper have been given the compositions of typical enamels applied to sheet steel together with reasons for their use. It has not been intended to cover the field of possible composition but it has been the purpose of the writer to present proven compositions which yield the several kinds of commercial enamels and enable the makers of enamels to compare them with their own.

Bureau of Standards
Washington, D. C.

Notice.—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

EXPERIMENTS IN AVENTURINE GLAZES*[1]

By H. G. Schurecht

Introduction

The name "aventurine" as applied to glazes, originated from its similarity in appearance to certain types of quartz and feldspar spangled with scales of mica, hematite or gothite. They give off firelike reflections when held in a bright light and are known as aventurine feldspar and aventurine quartz.

Wöhler[2] produced glazes having a similar appearance in 1849. Wartha[3] obtained an aventurine effect by first applying an engobe of iron or uranium oxide and then covering the same with a borax glaze.

Mäckler[4] determined the effect of increasing the iron oxide content in glazes of the cone 09 type and found that when 35 parts of iron oxide were added to 100 parts of glazes, he obtained an aventurine effect, but the color of the glaze was too dark, due to the reduction of the iron oxide to the ferrous condition. He, therefore, tried 20 per cent of finely ground metallic iron and obtained a transparent yellow glaze with many goldlike crystals. The glaze used by him corresponded to the following formula:

$$\left.\begin{matrix} 0.25\ K_2O \\ .25\ Na_2O \\ .50\ CaO \end{matrix}\right\} \begin{matrix} 2.25\ SiO_2 \\ 0.75\ B_2O_3 \end{matrix}$$

Patrik[5] produced artificial crystals of hematite by melting a mixture of iron sulphate and sodium chloride and dissolving in water. Crystals 1 to 2 mm. in diameter were produced in this

* Read Feb. 23, 1920, at the meeting of the Society in Philadelphia.

[1] By permission of the Director, U. S. Bureau of Mines.

[2] *Thonind. Ztg.*, **1896**, p. 219.

[3] *Ibid.*, **1890**, p. 170.

[4] *Ibid.*, **1890**, p. 207.

[5] *Ibid.*, **1896**, 275.

manner. These crystals are not easily dissolved in the glaze melt and when introduced into a glaze appear as bright scales similar to aventurine glazes.

Description of Work

In experiments conducted by the Bureau of Mines the effect of varying iron oxide and silica was studied between the following limits:

$$\left.\begin{matrix}0.4\ Na_2O \\ 0.6\ PbO\end{matrix}\right\} \left\{\begin{matrix}0.05\ Al_2O_3 \\ 0.25\ B_2O_3 \\ 0.12\text{–}0.81\ Fe_2O_3\end{matrix}\right\} 2.4\text{–}4.2\ SiO_2$$

A glaze free from lime was selected as CaO tends to destroy the desirable red or red-brown color in iron glazes.

The frit used is as follows:

$$\left.\begin{matrix}0.5714\ Na_2O \\ 0.4286\ PbO\end{matrix}\right\} \left\{\begin{matrix}0.375\ B_2O_3 \\ 0.171\ Fe_2O_3\end{matrix}\right\} 2.5\ SiO_2 \quad \text{Comb. Wt. } 333$$

Batch weight: Borax 955, nitrate of soda 933, white lead 1,548, red oxide of iron 384, flint 2,100.

The frit was ground through 100 mesh and used to make up the six end members, which correspond to the following formulas:

$$\text{A 1}\quad \left.\begin{matrix}0.4\ Na_2O \\ .6\ PbO\end{matrix}\right\} \left\{\begin{matrix}0.05\ Al_2O_3 \\ .25\ B_2O_3 \\ .33\ Fe_2O_3\end{matrix}\right\} 2.4\ SiO_2$$

$$\text{A 8}\quad \left.\begin{matrix}0.4\ Na_2O \\ .6\ PbO\end{matrix}\right\} \left\{\begin{matrix}0.05\ Al_2O_3 \\ .25\ B_2O_3 \\ .33\ Fe_2O_3\end{matrix}\right\} 4.2\ SiO_2$$

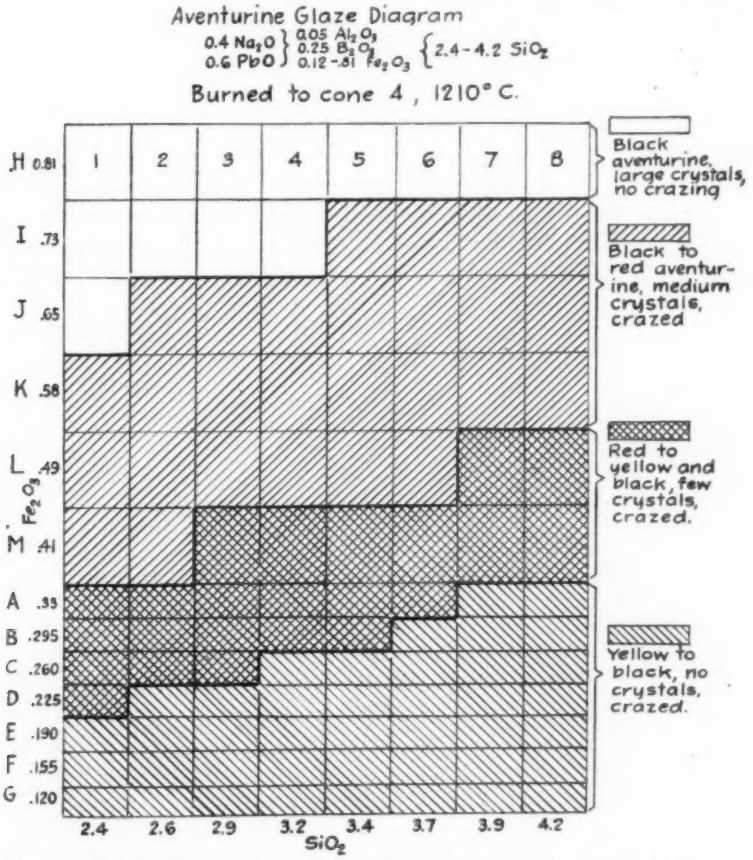
$$\text{G 1}\quad \left.\begin{matrix}0.4\ Na_2O \\ .6\ PbO\end{matrix}\right\} \left\{\begin{matrix}0.05\ Al_2O_3 \\ .25\ B_2O_3 \\ .12\ Fe_2O_3\end{matrix}\right\} 2.4\ SiO_2$$

$$\text{G 8}\quad \left.\begin{matrix}0.4\ Na_2O \\ .6\ PbO\end{matrix}\right\} \left\{\begin{matrix}0.05\ Al_2O_3 \\ .25\ B_2O_3 \\ .12\ Fe_2O_3\end{matrix}\right\} 4.2\ SiO_2$$

$$\text{H 1}\quad \left.\begin{matrix}0.4\ Na_2O \\ .6\ PbO\end{matrix}\right\} \left\{\begin{matrix}0.05\ Al_2O_3 \\ .25\ B_2O_3 \\ .81\ Fe_2O_3\end{matrix}\right\} 2.4\ SiO_2$$

$$\text{H 8}\quad \left.\begin{matrix}0.4\ Na_2O \\ .6\ PbO\end{matrix}\right\} \left\{\begin{matrix}0.05\ Al_2O_3 \\ .25\ B_2O_3 \\ .81\ Fe_2O_3\end{matrix}\right\} 4.2\ SiO_2$$

Batch weight	A 1	A 8	G 1	G 8	H 1	H 8
Frit	1166	1166	1166	1166	1166	1166
White lead	387	387	387	387	387	387
Red oxide of iron	168	168	...	...	552	552
Tenn. ball clay	65	65	65	65	65	65
Flint	165	705	165	705	165	705
	1951	2491	1783	2323	2335	2875



These end members were blended in different molecular proportions between the above limits as shown in tables 1 and 2.

The glazes were applied to whiteware trial pieces and fired in glazed saggers to cone 4 under oxidizing conditions. In some

early tests those glazes which contained a maximum of 0.33 Fe_2O_3 were made. No marked crystallization took place, therefore the iron content was increased to 0.81 Fe_2O_3.

In the diagram are shown the results obtained with the entire field of glazes. Apparently the best crystalline glazes are obtained when more than 0.41 Fe_2O_3 is employed for glazes with 2.4 SiO_2, and more than 0.58 Fe_2O_3 for glazes containing 4.2 SiO_2, *i. e.*, for high silica glazes more iron oxide is necessary to produce the aventurine crystal. The trials were fired under oxidizing conditions, but when fired under reducing conditions the tendency is to darken the glaze. A variety of colors varying from red to brown to black may be obtained by varying the kiln atmosphere from oxidizing through mildly reducing to strongly reducing. If the ware is not protected from kiln gases the glazes become a dull black with a metallic luster due to reduction of the ferric oxide to a lower form. If such reduced glazes are covered

TABLE 1—Aventurine Glazes

	A 1	A 8	G 1	G 8
1 A 1	100.0	....	....	....
1 A 2	82.5	17.5	....	....
1 A 3	66.2	33.8	....	....
1 A 4	51.1	48.9	....	....
1 A 5	37.0	63.0	....	....
1 A 6	23.8	76.2	....	....
1 A 7	11.5	88.5	....	....
1 A 8	....	100.0	....	....
1 B 1	84.5	....	15.5	....
1 B 2	69.7	14.8	12.7	2.8
1 B 3	55.9	28.6	10.2	5.3
1 B 4	43.1	41.3	7.9	7.7
1 B 5	31.3	53.1	5.7	9.9
1 B 6	20.1	64.2	3.7	12.0
1 B 7	9.7	74.6	1.8	13.9
1 B 8	....	84.3	....	15.7
1 C 1	68.6	....	31.4	....
1 C 2	56.5	12.1	25.8	5.6
1 C 3	45.3	23.2	20.7	10.8
1 C 4	34.9	33.5	16.0	15.6
1 C 5	25.3	43.0	11.6	20.1
1 C 6	16.3	52.0	7.5	24.2
1 C 7	7.9	60.4	3.6	28.1

1 C 8	....	68.2	....	31.8
1 D 1	52.2	....	47.8	....
1 D 2	43.0	9.2	39.3	8.5
1 D 3	34.5	17.6	31.5	16.4
1 D 4	26.6	26.4	24.3	23.7
1 D 5	19.2	32.7	17.6	30.5
1 D 6	12.4	39.5	11.3	36.8
1 D 7	6.0	45.8	5.5	42.7
1 D 8	....	51.7	....	48.3
1 E 1	35.4	....	64.6	....
1 E 2	29.1	6.2	53.2	11.5
1 E 3	23.3	11.9	42.6	22.2
1 E 4	17.9	17.2	32.8	32.1
1 E 5	13.0	22.1	23.7	41.2
1 W 6	8.3	26.7	15.3	49.7
1 E 7	4.0	30.9	7.4	57.7
1 E 8	....	34.9	....	65.1
1 F 1	18.0	....	62.0	....
1 F 2	14.8	3.1	67.5	14.6
1 F 3	11.8	6.0	54.0	28.2
1 F 4	9.1	8.7	41.6	40.6
1 F 5	6.6	11.2	30.0	52.2
1 F 6	4.2	13.5	19.3	63.0
1 F 7	2.0	15.7	9.3	73.0
1 F 8	....	17.7	....	82.3
1 G 1	....	....	100.0	....
1 G 2	....	....	82.2	17.8
1 G 3	....	....	65.7	34.3
1 G 4	....	....	50.6	49.4
1 G 5	....	....	36.5	63.5
1 G 6	....	....	23.5	76.5
1 G 7	....	....	13.9	86.1
1 G 8	....	....	....	100.0

TABLE 2—Aventurine Glazes

	H 1	H 8	A 1	A 8
1 H 1	100.00	...	...	...
1 H 2	83.12	16.88	...	...
1 H 3	67.00	33.00	...	...
1 H 4	52.20	47.80	...	...
1 H 5	38.05	61.95	...	...
1 H 6	24.98	75.02	...	...
1 H 7	12.03	87.97	...	...
1 H 8	...	100.00	...	...
1 I 1	85.80	...	14.20	...
1 I 2	71.21	14.45	11.80	2.54

TABLE 2 (*Continued*)

	H 1	H 8	A 1	A 8
1 I 3	57.48	28.07	9.90	4.66
1 I 4	44.54	41.08	7.30	7.08
1 I 5	32.53	53.07	5.40	9.10
1 I 6	21.02	64.27	3.47	11.12
1 I 7	10.24	75.06	1.70	13.00
1 I 8	...	85.23	...	14.77
1 J 1	70.71	...	29.29	...
1 J 2	57.44	11.68	25.83	5.05
1 J 3	47.30	23.10	19.60	10.00
1 J 4	36.67	33.57	15.20	14.56
1 J 5	26.58	43.27	11.02	19.13
1 J 6	17.28	52.76	7.18	22.83
1 J 7	8.42	61.17	3.52	26.84
1 J 8	...	69.78	...	30.22
1 K 1	55.37	...	44.53	...
1 K 2	45.30	9.22	37.53	7.95
1 K 3	36.50	17.82	30.23	15.45
1 K 4	28.27	25.89	23.42	22.42
1 K 5	20.55	33.45	17.02	28.98
1 K 6	13.34	40.54	10.96	35.14
1 K 7	6.44	47.26	5.35	40.95
1 K 8	...	53.58	...	46.42
1 L 1	33.55	...	66.45	...
1 L 2	31.12	6.33	51.58	10.97
1 L 3	25.06	12.23	41.51	21.23
1 L 4	19.38	17.75	32.12	30.75
1 L 5	14.07	22.91	23.31	39.71
1 L 6	9.10	27.75	15.06	48.09
1 L 7	4.44	31.92	7.35	56.29
1 L 8	...	36.65	...	63.35
1 M 1	19.45	...	80.55	...
1 M 2	16.02	8.26	66.50	14.16
1 M 3	12.90	6.30	53.60	27.30
1 M 4	9.98	9.13	41.32	39.57
1 M 5	7.23	11.78	29.97	51.02
1 M 6	4.63	14.25	19.33	61.78
1 M 7	2.27	16.57	9.37	71.78
1 M 8	...	18.75	...	81.25

with a thin coating of a raw lead glaze of the following composition and fired under oxidizing conditions, a maroon color is obtained.

$$\left.\begin{matrix} 0.6\ PbO \\ .15\ K_2O \\ .10\ CaO \\ .15\ FeO \end{matrix}\right\} \begin{matrix} \text{Cone 02} \\ 0.2\ Al_2O_3 \quad 2.0\ SiO_2 \end{matrix}$$

Increasing the iron content seems to increase the size and number of crystals in the glaze and also requires a higher temperature for its development.

Slow cooling seems essential for the development of large crystals.

Summary

Within the foregoing experimental limits aventurine glazes were obtained with more than 0.41 Fe_2O_3 in glazes containing 2.4 SiO_2, and with more than 0.58 Fe_2O_3 in glazes containing 4.2 SiO_2.

Glazes with 0.41 to 0.73 Fe_2O_3 vary in color from red to black according to kiln conditions, red being produced under oxidizing conditions and black under reducing conditions.

With strong reducing conditions the glazes high in iron become a dull black with a metallic luster. By applying a thin coating of a cone 02 lead glaze on the surface of such a glaze and firing in an oxidizing atmosphere, a maroon effect is obtained.

Increasing the iron content increases the size and number of crystals and also the refractoriness of the glaze.

In conclusion the author wishes to acknowledge his indebtedness to Mr. R. T. Stull for assistance in this work.

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NOTICE—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

TIME AND TEMPERATURE OF BURNING AS FACTORS INFLUENCING THE CONSTITUTION AND MICRO-STRUCTURE OF A PORCELAIN BODY*

By A. A. Klein

In Technologic Paper of the Bureau of Standards No. 80 by the writer on the constitution and micro-structure of porcelain, it is concluded that the effect of higher temperatures on determining the constitution and micro-structure of a porcelain body is of much greater importance than the length of time of soaking at the maximum temperature. Some exceptions have been taken to this conclusion, namely by Peck[1] and by Mellor.[2] The conclusions reached by both of these investigators indicated that the time of soaking was a very important factor, perhaps even as important as the actual maximum temperature of burning.

During the past year the writer had occasion to examine a body containing flint, feldspar and clay which had been subjected to successive burning at the same temperature. The data really confirmed those reached in Technologic Paper No. 80.

Owing to the pressure of other work it was impossible to make a very broad investigation of this point; but the Onondaga Pottery Company was communicated with, and through the courtesy of Mr. Pass, several samples of green tableware were procured.

These were burned in a kiln fired to cone 13–14, the temperature as determined by pyrometer being close to 1348° C. In this kiln the soaking period varied from 12 to 18 hours. Six samples were put through one burn, five through two, four through three and so on. Thus there was obtained a collection of samples which had been through from one to six burns. The soaking periods, therefore, were from 12–18 hours to 72–108 hours. In addition one sample was fired in a gas fired pot furnace to cone 15 soaking one hour.

* Received Feb. 27, 1920.

[1] *Jour. Amer. Ceram. Soc.*, **2**, 175–194 (1919).

[2] *Trans. Amer. Ceram. Soc.*, **16**, 71 (1914).

The following facts were observed with the body subjected to one burn at cone 13–14 (see figures 1 and 2). The feldspar had

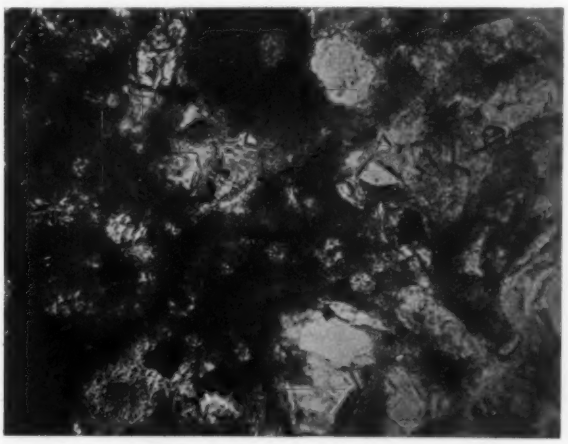

FIG. 1.—Showing body given one burn at cone 13–14 taken in ordinary light. Note the translucent character of the glass due to amorphous sillimanite. Note also the angularity of the quartz grains. Magnification = 200 diameters.

FIG. 2.—Same as figure 1 but taken in plane polarized light with crossed nicols. This brings out some of the quartz grains which are not in extinction.

completely melted and formed a glass. The kaolin had completely dissociated with the formation of amorphous sillimanite predominating and an extremely small amount of fine crystalline

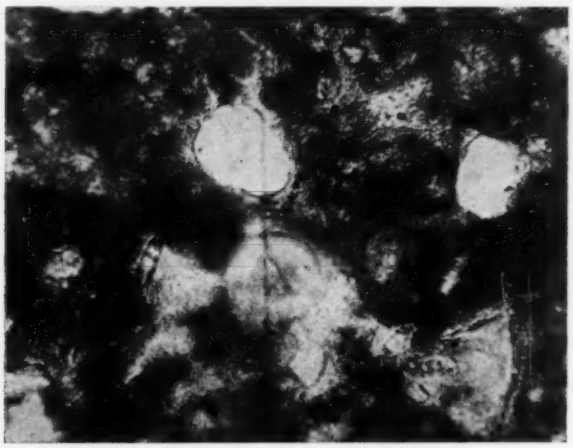

FIG. 3.—Showing body given 3 burns of cone 13–14. Note the similarity of the data with those of figure 1. Magnification = 200 diameters.

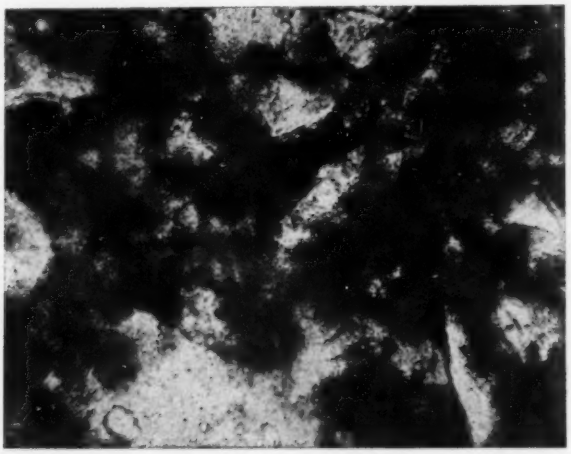

FIG. 4.—Showing body given 4 burns at cone 13–14. Note the similarity to figure 1. Magnification = 200 diameters.

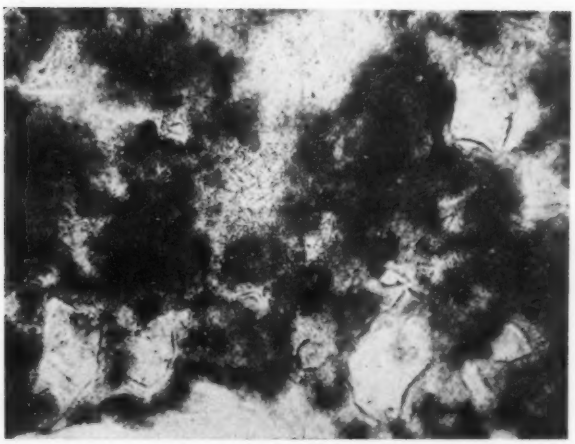

FIG. 5.—Showing body burned 5 times at cone 13–14 taken in ordinary light. Note the small amount of sillimanite crystals and the rather small progress of quartz solution. Magnification = 200 diameters.

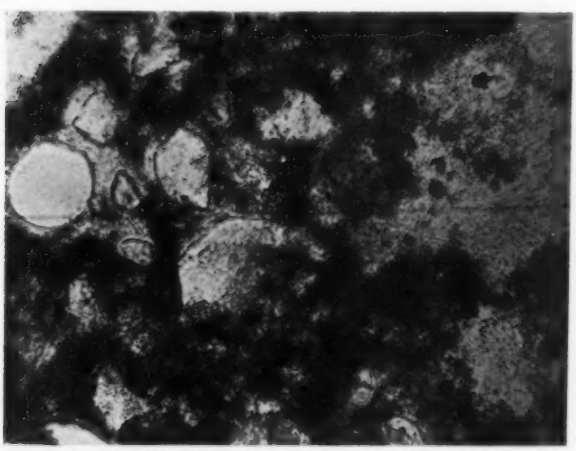

FIG. 6.—Showing body burned 6 times at cone 13–14 taken in ordinary light. Note the similarity of data to those of figure 5. Magnification = 200 diameters.

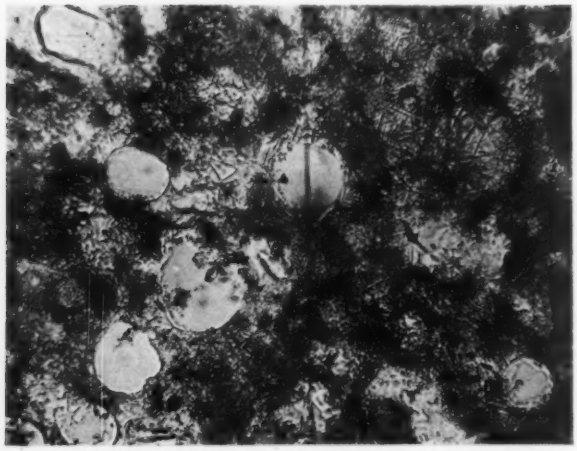

FIG. 7.—Showing body soaked one hour (direct fire) at cone 15 taken in ordinary light. Note the amount and development of sillimanite crystals as well as the amount of quartz solution and its effect upon the contour of the quartz grains. Magnification = 200 diameters.

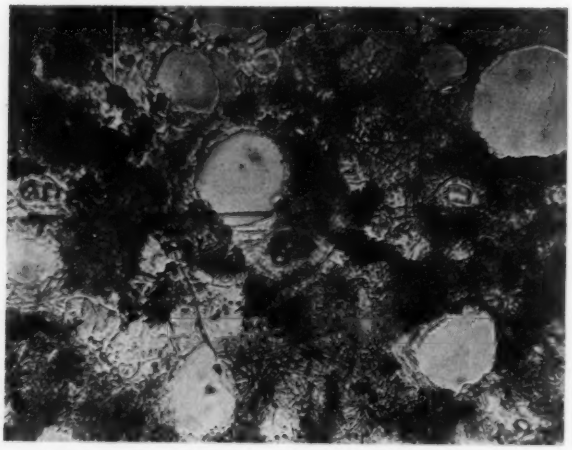

FIG. 8.—Showing body soaked one hour (muffled) at cone 15. Compare with figure 6. Magnification = 200 diameters.

sillimanite. Furthermore, with the exception of a small amount of quartz solution in the very small grains, there was practically no evidence of this phenomenon.

The effect of the additional burns through six times (see figures 3, 4, 5, 6) was substantially as follows. There was a small increase in the amount as well as the development of sillimanite crystals, but in every case the amorphous material predominated. There was also a decrease in the amount of quartz present as the number of burns increased, the amount being determined quantitatively as follows, approximately 30 per cent for the sample burned once as against about 15 per cent for that burned six times. As may be expected the outlines of the quartz grains upon repeated burning showed more and more rounding due to solution.

The data found with the body burned at cone 15 (see figures 9, 10) soaked for one hour differed materially from those of the body given the maximum soaking at the lower temperature. Practically no amorphous sillimanite was present and the crystals of this constituent attained comparatively considerable size. Only the larger quartz crystals still remained and these showed the typical elliptical outlines resulting from profound solution. The amount of this constituent was approximately six per cent.

The accompanying photographs bring out these points and show conclusively that the difference between the short burn at high temperature and six burns at the lower temperature was by far greater than the difference between one and six burns at the lower temperature. We, therefore, feel justified in stating at least for this body, which is a typical American tableware body, that the actual temperature of burning has a much more marked effect on its constitution and structure than the time of soaking.

NORTON COMPANY
WORCESTER, MASS.

NOTICE—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

RESULTS OF TESTING GYPSUM PRODUCTS*

By W. E. Emley and C. F. Faxon

In an effort to write standard specifications for gypsum, many difficulties have been encountered. Probably the greatest source of confusion was the attempt to adopt verbatim the standard methods of test which were in use in the examination of other similar materials. Experience showed the futility of this procedure, and finally compelled the invention of new methods of test, designed especially for gypsum. After considerable deliberation and experiment, a number of methods of test were finally agreed upon and adopted as tentative.[1]

It then developed that no one had had enough experience with these new methods to be able to predict what numerical results they would give. For example, take the tensile strength. This property of gypsum was pretty well known when measured by any one of several different methods. The method adopted, however, introduced certain innovations, so that no one could foretell just what tensile strength a given sample of material would have when tested by this new method.

Obviously some information about these numerical results was essential, in order that specifications could be intelligently written. It would be absurd to specify a tensile strength of 300 pounds per square inch, and then discover that either all or none of the gypsum on the market met the requirement.

Accordingly the Bureau of Standards undertook to test a number of commercial samples. This article is a compilation of the results obtained. The tests were carried out on 43 samples, made by three different manufacturers. Of these, 25 were shipped to us direct from the factory, packed in air-tight glass containers; 8 came direct from the factory, in the usual commercial package; and 10 were obtained from dealers.

* Received Sept. 1, 1920.

[1] American Society for Testing Materials, C-26–19T.

While an attempt was made to follow the methods of test cited above, certain changes and additions were found advisable and were accordingly made. A brief description of the methods is as follows:

1. **Chemical Analysis.**—Lime, sulphuric anhydride, carbon dioxide, and loss on ignition, were determined by the usual methods of chemical analysis.[1] These constituents were then combined as follows: The amount of lime required to combine with the carbon dioxide was found by multiplying the per cent carbon dioxide by 56/44. The per cent lime present as carbonate was deducted from the total per cent lime. The per cent water was found by subtracting the per cent carbon dioxide from the per cent loss on ignition. From the figures for lime, sulphuric anhydride, and water, the maximum possible content of calcined gypsum ($CaSO_4.{}^1/_2H_2O$) was calculated, using the ratios 56:80:9. Usually two, and always one of these three ingredients was found to be in excess of these ratios. This was taken to indicate the presence of some foreign material, such as calcium hydroxide, magnesium sulphate, anhydrous calcium sulphate, etc.

2. **Normal Consistency.**—This is the number of cubic centimeters of water which must be added to 100 grams of dry material to produce a paste of standard "wetness." It was determined by means of the Southard viscosimeter,[2] the standard wetness being such that the final radius of the pat was 9.6 cms.

3. **Time of Set.**—This is measured by means of a Vicat needle, on material of normal consistency. It is the elapsed time from when the sample is added to the water to when the needle fails to penetrate to the bottom of the pat.

4. **Fineness.**—This is expressed as the per cent by weight of the material separated by six sieves of different meshes. The sieves used were the Nos. 8, 14, 28, 48, 100 and 200. In general, the material could be screened dry through Nos. 8 and 14, but had to be washed with kerosene in order to get clean separations on the finer sieves.

[1] Hillebrand, "Analysis of Silicate and Carbonate Rocks," U. S. Geol. Sur., *Bull.* **700**.

[2] A. S. T. M., C26–19T.

5. Compressive Strength.—Three cylinders, 2 inches in diameter by 4 inches high, were made of paste of normal consistency. They were removed from the molds as soon as they were hard enough to handle (1 to 24 hours), stored in the air in the room for one week, and tested. The results are expressed as pounds square inch.

TABLE 1

Lab. No.	Trade name of material	Class
1	Unretarded gauging plaster	Calcined gypsum only
2	Molding plaster	
10	Unretarded gauging plaster	
11	Molding plaster	
19	Unretarded gauging plaster	
20	Molding plaster	
26	Stucco	
28	Molding plaster	
29	Reground stucco	
31	Stucco	
32	Stucco	
34	Plaster of Paris F	
35	Plaster of Paris FFF	
37	Windsor cement FFF	
43	Potters plaster	
Ave.		
3	Retarding gauging plaster	Calcined gypsum plus retarder
4	Cement plaster, unsanded, not fibered	
12	Retarded gauging plaster	
13	Cement plaster, unsanded, not fibered	
21	Retarded gauging plaster	
22	Cement plaster, unsanded, not fibered	
38	Ready finish	
41	Superfine Windsor cement	
Ave.		
5	Cement plaster, unsanded, fibered	Calcined gypsum plus retarder plus fiber
16	Retarded fibered cement plaster	
23	Fibered cement plaster	
27	Fibered plaster	
33	Fibered plaster	
36	Windsor cement, neat	
Ave.		

6	Wood fiber plaster to be used with sand	Calcined gypsum plus retarder plus wood fiber
7	Wood fiber plaster	
14	Wood fiber plaster to be used with sand	
15	Retarded wood fiber plaster	
24	Wood fiber plaster to be used with sand	
25	Wood fiber cement	
30	Wood fiber plaster	
39	Windsor cement for concrete	
42	Wood fiber plaster	
Ave.		
9	Ready mixed brown coat	Calcined gypsum plus retarder plus sand
18	Ready mixed brown coat	
Ave.		
8	Ready mixed scratch coat	Calcined gypsum plus retarder plus fiber plus sand
17	Ready mixed scratch coat	
40	Brown mortar	
Ave.		

TABLE 2

	Chemical analysis					
	Found				Calculated	
Lab No.	CaO	CO_2	SO_3	Loss on ignition	Calcined gypsum	Constituents in excess
1	37.60	4.21	48.73	10.40	83.50	$SO_3.H_2O$
2	37.20	4.22	49.00	10.70	82.40	$SO_3.H_2O$
10	34.80	12.53	36.80	16.20	48.77	$SO_3.H_2O$
11	35.28	11.00	38.55	16.40	55.10	$SO_3.H_2O$
19	38.12	0.56	53.50	8.00	97.02	$CaO.H_2O$
20	38.24	.74	53.64	8.00	86.60	$SO_3.H_2O$
26	38.20	.10	54.00	7.60	97.88	$CaO.H_2O$
28	37.94	.10	53.90	7.70	97.69	$CaO.H_2O$
29	35.80	2.40	47.80	9.20	84.83	$SO_3.H_2O$
31	37.44	0.60	51.90	7.90	94.07	$CaO.H_2O$
32	37.10	4.10	48.70	10.60	82.54	$SO_3.H_2O$
34	38.00	1.00	51.65	7.53	93.65	$CaO.H_2O$
35	38.26	0.62	53.70	6.91	97.10	$SO_3.H_2O$
37	38.13	.53	53.80	6.94	97.00	$SO_3.H_2O$
43	38.90	.70	53.60	7.55	97.15	$CaO.H_2O$
Ave.	37.41	2.89	49.98	9.44	87.02	
3	37.04	4.53	48.28	10.90	83.50	$SO_3.H_2O$
4	36.72	4.37	47.90	10.75	80.60	$SO_3.H_2O$
12	34.52	10.02	36.49	17.35	56.35	$SO_3.H_2O$
13	34.84	12.33	37.56	16.55	49.58	$SO_3.H_2O$
21	38.60	0.81	53.30	7.55	96.60	$CaO.H_2O$
22	38.28	.84	53.74	8.10	96.40	$SO_3.H_2O$

TABLE 2 (*Continued*)

	Chemical analysis					
	Found				Calculated	
Lab. No.	CaO	CO_2	SO_3	Loss on ignition	Calcined gypsum	Constituents in excess
38	39.20	2.83	15.55	14.20	28.20	$CaO.H_2O$
41	35.72	15.20	35.90	20.05	42.38	$SO_3.H_2O$
Ave.	36.86	6.37	41.09	13.18	66.70	
5	36.96	4.73	47.83	11.15	80.20	$SO_3.H_2O$
16	35.00	12.16	37.90	17.15	50.56	$SO_3.H_2O$
23	36.88	0.68	52.30	7.35	93.30	$SO_3.H_2O$
27	38.24	.40	53.90	7.90	97.68	$SO_3.H_2O$
33	37.70	.10	53.40	7.80	96.79	$CaO.H_2O$
36	36.88	1.40	48.50	8.18	87.95	$CaO.H_2O$
Ave.	36.94	3.24	48.97	9.92	84.41	$CaO.H_2O$
6	36.92	4.36	48.52	10.70	81.20	$SO_3.H_2O$
7	37.00	4.41	48.59	10.50	81.25	$SO_3.H_2O$
14	34.96	12.64	37.32	17.35	48.86	$SO_3.H_2O$
15	35.12	11.90	38.10	17.40	51.70	$SO_3.H_2O$
24	38.20	0.74	53.64	7.90	96.47	$SO_3.H_2O$
25	38.08	.82	53.06	7.95	95.95	$SO_3.H_2O$
30	36.14	2.50	48.40	9.40	85.34	$SO_3.H_2O$
39	27.41	1.64	27.70	9.25	50.22	$CaO.H_2O$
42	35.40	1.31	46.40	8.60	84.10	$CaO.H_2O$
Ave.	35.47	4.48	44.64	11.01	75.01	$CaO.H_2O$
9	18.20	10.86	13.49	13.10	11.27	$SO_3.H_2O$
18	25.60	15.70	13.68	17.80	14.50	$SO_3.H_2O$
Ave.	21.90	13.28	13.58	15.45	12.88	
8	18.52	10.32	14.80	12.75	13.92	$SO_3.H_2O$
17	24.80	13.86	15.84	16.70	18.49	$SO_3.H_2O$
40	8.76	0.47	10.80	3.09	19.58	$CaO.H_2O$
Ave.	17.36	8.22	13.81	10.85	17.33	

TABLE 3

	Fineness						
Lab. No.	On 8	8–14	14.28	28–48	48–100	100–200	Through 200
1	...	0.1	0.1	0.9	3.9	15.4	79.6
2	...	...	.2	1.1	4.1	8.2	86.4
10	...	.1	.3	4.6	7.0	11.5	76.5
11	...	.1	.1	.3	0.7	6.8	92.0
19	...	.1	.3	3.0	24.0	26.7	45.9
20	...	...	.1	0.5	6.3	23.2	69.9

26	...	...	.3	4.0	15.6	29.7	50.4
28	...	...	.1	0.3	4.8	15.6	79.2
29	...	...	.7	3.8	8.5	20.3	66.7
31	...	...	.1	0.4	1.1	9.1	89.3
32	...	...	.2	1.3	3.1	8.2	87.2
34	0.3	0.7	2.5	8.8	16.4	11.1	60.2
35	...	...	...	0.2	9.3	13.4	77.1
37	...	...	...	.1	6.1	9.7	84.1
43	...	...	...	.3	4.9	13.2	81.6
Ave.	0.0	0.1	0.3	2.0	7.7	14.5	75.1
3	...	...	0.2	0.9	3.1	10.7	85.1
4	...	...	.1	1.3	4.1	12.4	82.1
12	...	0.1	.3	4.1	8.9	8.8	77.8
13	...	...	.1	0.2	1.2	4.7	93.8
21	...	...	.2	2.5	18.0	28.7	50.6
22	...	...	.3	2.2	18.6	21.5	57.4
38	...	...	...	0.2	2.6	7.7	89.5
41	...	...	...	1.7	14.1	10.3	73.9
Ave.	0.0	0.0	0.1	1.6	8.8	13.1	76.3
5	0.1	0.1	0.1	0.9	3.3	10.8	84.7
16	.1	.1	.1	.2	0.8	6.4	92.3
23	.1	.1	.2	1.7	14.8	21.9	61.2
27	...	...	.2	0.9	2.8	17.0	79.1
33	...	...	.3	1.5	4.8	28.7	64.7
36	0.1	0.4	2.3	13.5	16.8	9.6	57.4
Ave.	.1	.1	0.5	3.1	7.2	15.9	73.2
6	0.5	0.4	0.5	1.7	3.8	9.7	83.4
7	.7	.3	.3	1.7	4.0	10.7	82.3
14	.4	.2	.4	4.0	8.9	11.0	75.1
15	.4	.2	.4	3.7	8.6	9.5	77.2
24	.8	.5	.6	2.7	17.5	19.3	58.6
25	.4	.1	.4	2.6	19.5	22.6	54.4
30	.1	.2	1.2	3.5	9.7	22.4	62.9
39	1.5	4.2	7.5	16.0	17.5	6.6	46.7
42	0.3	0.6	1.1	8.5	23.5	9.4	56.6
Ave.	.6	.8	1.4	4.9	12.6	13.5	66.4
9	0.1	8.9	10.9	18.0	25.4	16.7	20.0
18	.8	21.2	21.6	10.8	11.4	3.8	30.4
Ave.	.4	15.0	16.2	14.4	18.4	10.2	25.2
8	0.2	10.3	11.3	12.8	21.2	13.7	30.5
17	3.6	30.0	12.8	6.5	10.0	4.4	32.7
40	0.5	5.3	10.2	31.4	26.0	8.0	18.6
Ave.	1.4	15.2	11.4	16.9	19.1	8.7	27.3

TABLE 4

Lab. No.	Compressive strength	Yield			Tensile strength	Normal consistency	Time of set
		Lbs. paste per cu. ft.	Lbs. dry material per cu. ft. paste	Lbs. set material per cu. ft.			
1	1460	106	64	76	254	66.1	21
2	1315	107	64	75	775	66.9	21
10	1700	113	77	88	333	46.6	12
11	1570	107	66	79	270	56.2	7
19	1105	101	58	68	244	73.2	11
20	1060	102	58	68	220	75.0	19
26	1550	113	74	82	413	53.0	14
28	1580	112	72	81	387	56.0	22
29	1956	114	77	89	357	48.0	16
31	1935	107	68	78	394	58.0	8
32	1875	110	72	83	444	51.8	12
34	2200	114	76	85	437	50.0	13
35	1630	111	69	79	280	60.2	9
37	2285	116	75	83	299	51.5	8:00
43	1720	92	57	78	270	61.0	9:00
Ave.	1665	108	62	80	325	58.2	13:00
3	1295	107	65	77	273	64.3	53:00
4	925	105	63	74	236	66.0	11:56
12	1420	111	76	87	290	46.2	2:54
13	630	112	74	85	218	51.9	17:23
21	1280	103	62	73	272	65.4	1.58
22	1000	103	62	73	261	65.0	13:07
38	145	93	50	54	37	85.5	1:00
41	1400	120	83	87	129	44.6	5:37
Ave.	1010	107	67	76	215	61.1	6:41
5	555	104	63	73	182	65.7	14:15
16	1100	110	73	80	254	51.2	25:24
23	1030	106	66	75	269	61.0	13:09
27	1730	107	69	81	379	55.5	6:34
33	1475	115	75	83	400	53.3	8:50
36	800	107	70	80	186	51.6	19:42
Ave.	1115	108	69	79	278	56.4	14:39
6	835	103	62	73	222	65.4	18:35
7	670	103	62	74	195	66.3	6:17
14	785	108	73	86	223	47.1	11:26
15	885	109	75	87	259	45.7	6:20
24	960	99	61	73	228	63.0	10:30
25	910	101	60	71	232	67.4	12:24

30.....	1480	104	70	85	372	48.6	9:10
39.....	275	115	75	78	73	53.0	3:10
42.....	710	107	69	81	120	53.7	4:45
Ave.....	835	106	67	79	214	56.7	9:11
9.....	195	129	101	108	52	27.0	2:19
18.....	475	131	106	111	109	23.1	2:32
Ave.....	335	130	103	109	80	25.0	2:30
8.....	200	126	98	104	53	29.0	1:52
17.....	865	130	106	112	198	22.2	4:51
40.....	180	120	95	103	37	25.8	3:27
Ave.....	415	125	100	106	96	25.7	3:23

6. Yield.—The above cylinder molds were weighed empty, and immediately after filling. The cylinders were weighed just before they were tested. The amount of dry material in a given volume of paste was calculated from the figure for normal consistency. These data were used to calculate the weight per cubic foot of paste, the weight of dry material per cubic foot of paste, and the weight per cubic foot of set material.

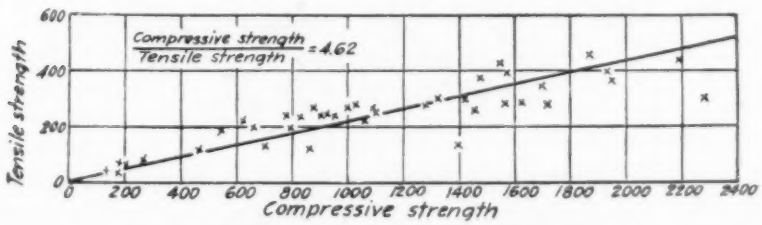

FIG. 1.—Compressive strength *vs.* tensile strength.

7. Tensile Strength.—Three briquettes of the usual form were made of paste of normal consistency, stored in the same way as the compressive strength specimens, and tested when one week old. The results are expressed in pounds per square inch.

The results of all of these tests are given in the accompanying tables. Owing to the extremely confusing nomenclature, no attempt has been made to group the samples according to their trade names. They have been classified, instead, in accordance with their actual compositions.

Primarily, these data are intended to enable us to arrive at numerical values expressing the different properties of gypsum.

These values are to be used in writing specifications for the material. Incidentally, the data may also be used in an attempt to correlate the various properties. Certain efforts along this line are indicated in figures 1 and 2, showing the relations between

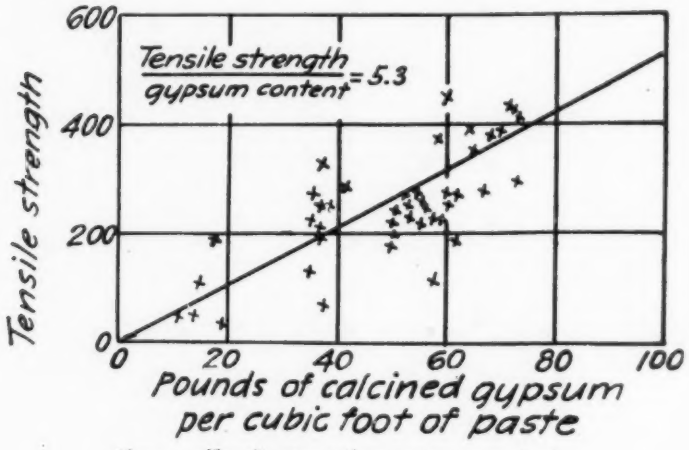

FIG. 2.—Tensile strength *vs.* gypsum content.

tensile strength and compressive strength, and tensile strength and gypsum content, respectively. Obviously the data permit and invite a great deal of this sort of calculation.

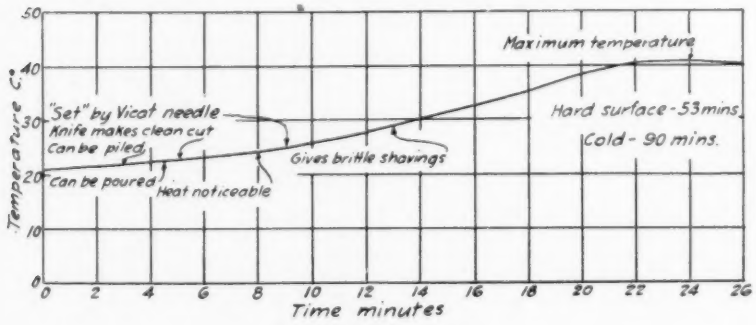

FIG. 3.—Time of set.

It seems that the present method of measuring time of set by means of the Vicat needle has been the subject of much criticism.

To get more information on this point, the times of set of ten samples were measured by means of the temperature rise, and by direct observation. The results for one of these samples are given in figure 3. All of these results confirm those previously[1] obtained: that the temperature rise method is fundamentally unsound, and is misleading. The Vicat needle is endorsed. It gives results which are definite, which can be checked, and which indicate the time during which gypsum may be worked without injury.

The use of the Southard viscosimeter to measure normal consistency has also been criticized. The results obtained by means of this instrument are probably accurate within 1 per cent, and can be readily checked by different observers. The machine is not portable, and its use is therefore confined to the laboratory. It was suggested that a cylinder mold two inches in diameter by four inches long could easily be carried in the pocket, and a "slump" test, using this mold, would measure consistency to a sufficient degree of accuracy. Accordingly, pastes of normal consistency (by the Southard viscosimeter) were made of 10 samples, and were tested by the slump method, using a two by four inch cylinder. It was found that the final diameter of the pat varied from $4^1/_4$ to $5^1/_2$ inches for the different samples. It would seem, therefore, that the slump method is hardly accurate enough for a standard method, although it will probably give satisfaction when used for plant control.

We wish to acknowledge our obligations to Mr. H. A. Bright for the analytical work, and to Mr. L. A. Balser for assistance in making physical measurements.

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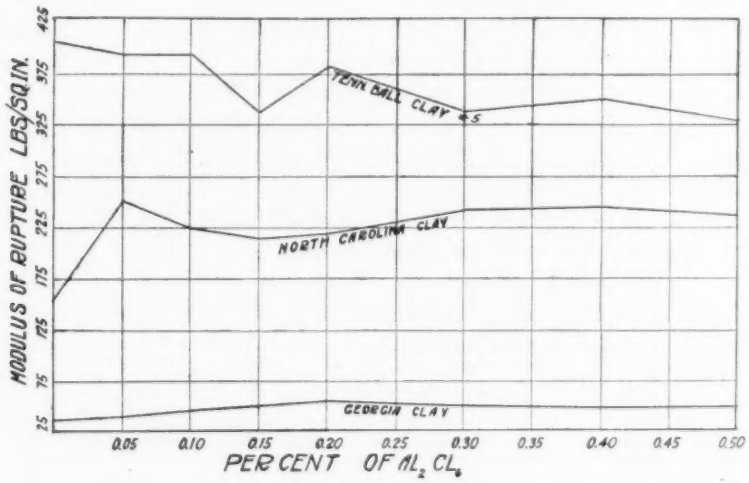
NOTICE—*Further discussion of this subject is solicited. All communications should be sent to the Editor.*

[1] Emley, "Time of Set of Calcined Gypsum," *Trans. Amer. Ceram. Soc.*, **19**, p. 573 (1917).

THE EFFECT OF ALUMINUM CHLORIDE UPON CLAYS*

By H. P. Reinecker and J. S. George, Washington, D. C.

In several potteries manufacturing vitreous table ware it has become a practice to add aluminum chloride to the body slip previous to the ball mill grinding. In all cases of this kind the composition contains but a comparatively small amount of ball clay and a predominating proportion of kaolin with respect to the total content of clay substance. The reason given for the use of aluminum chloride is that the working quality of the body is improved, presumably through the neutralization of any free alkali resulting from the wet grinding of the feldspar. There are others however who deny that any beneficial result arises from the use of the reagent.



EXPERIMENTAL

It was thought desirable therefore to conduct a few experiments along these lines in order to determine if possible what the effect of the chloride might be. The work was of a simple

* Received Feb. 27, 1920.

character and consisted merely in the addition of increasing amounts of aluminum chloride, varying from 0.05 to 0.5 per cent of the dry weight of three clays, the North Carolina and Georgia kaolins and Tennessee ball clay 5. The reagent was added to the clay in solution. In a supplementary series of experiments sufficient NH_4HO was used to precipitate the alumina as the hydroxide with, of course, the simultaneous formation of ammonium chloride. This was done for the purpose of ascertaining the difference in the effect produced between the aluminum chloride in solution and the colloidal hydroxide in the presence of NH_4Cl.

The clays thus treated were made into briquettes and bars and the water of plasticity, volume drying shrinkage and modulus of rupture in the dried state determined. The water of plasticity and shrinkage determinations are based on three specimens and the transverse strengths represent the average of six bars. The results of this work are compiled in the accompanying table:

TABLE 1

Al_2Cl_6 added	Al_2Cl_6 added with (NH_4HO)	Water of plasticity per cent of dry weight			Drying shrinkage in terms of dry vol.			Modulus of rupture in dry state, lbs. per sq. in.		
Per cent	Per cent	N. C.	Ga.	Tenn.	N. C.	Ga.	Tenn.	N. C.	Ga.	Tenn.
0.00	..	44.63	39.84	47.32	29.2	18.9	34.30	160	37	404
.05	..	40.17	40.10	45.33	23.6	18.7	33.05	251	41	393
.10	..	40.64	39.50	48.07	25.6	18.3	35.60	225	46	393
.15	..	42.05	38.35	49.33	26.7	18.2	36.40	214	51	337
.20	..	41.77	38.20	49.83	27.1	17.65	36.70	219	56	382
.30	..	42.69	37.80	49.01	27.3	17.55	34.75	244	57	338
.4	..	43.20	39.36	49.03	29.0	19.85	34.10	249	48	353
.5	..	42.35	38.29	49.05	28.9	18.35	33.80	239	49	329
..	0.05	42.97	38.59	48.98	27.05	16.20	35.20	142	57	329
..	.10	42.03	39.12	48.40	25.90	17.0	34.70	151	67	413
..	.15	43.37	39.48	49.78	27.4	17.05	34.85	160	65	333
..	.20	40.62	38.74	50.06	25.3	16.60	35.15	167	57	367
..	.30	43.41	42.61	51.2	27.5	20.3	34.80	172	61	304
..	.40	44.16	41.77	54.79	28.7	19.45	37.30	182	70	236
..	.50	43.05	42.28	53.73	27.85	19.75	35.80	213	62	280

Discussion of Results

It is at once apparent from the results obtained that the effect of aluminum chloride shows phases of maxima and minima as found in the previous work of Bleininger and Fulton, of Back, Schurecht and others.

It appears that additions of aluminum chloride, without and with the use of ammonia, do not bring about decided changes in the amounts of water of plasticity, the greatest change being observed with 0.4 and 0.5 per cent of Al_2Cl_6 plus NH_4HO.

The addition of aluminum chloride alone reduced the drying shrinkage of the North Carolina and the Georgia kaolin, though an exception is noted in the case of the latter with 0.4 per cent. The Tennessee ball clay shows alternate phases of reduced and increased shrinkage, a condition typical of all systems of this kind. Practically the same statements apply to the use of Al_2Cl_6 plus ammonia.

The only clay whose strength in the dry state is markedly improved by the addition of Al_2Cl_6 alone is the North Carolina kaolin. A much less marked gain in strength is observed with the Georgia kaolin and a decided decrease in strength by the Tennessee ball clay. The further addition of NH_4HO practically neutralizes the gain due to the use of Al_2Cl_6 in North Carolina kaolin except when as much as 0.5 per cent is used. The ammonical condition on the other hand increased the gain in strength of the Georgia kaolin but brought about no marked change over the use of Al_2Cl_6 alone.

It would seem then that the use of aluminum chloride increases the mechanical strength of the primary kaolin exercising but a much less marked influence in the same direction on the secondary kaolin and decreasing the strength of the ball clay. The effects observed are evidently due to the salt in solution, and the acidity caused by the dissociation of the Al_2Cl_6. With larger amounts of aluminum hydroxide present a gain in strength may be brought about by the colloidal precipitate formed.

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THE USE OF AMERICAN RAW MATERIALS IN THE MANUFACTURE OF WHITEWARE POTTERY

By A. V. Bleininger and W. W. McDanel

DISCUSSION

Mr. C. Merts Franzheim.—The article appearing in the February issue of the magazine on "The use of American raw materials in the manufacture of whiteware pottery," giving in detail the results of extensive experiments by Mr. A. V. Bleininger and W. W. McDanel has made a solid contribution to the subject of the use of American clays. I should like to answer this article in brief.

The writer has for many years been interested in various connections in the development of American clay mines, has visited many, and has been instrumental in aiding in the production and actual marketing of the output, having in mind a product which would prove satisfactory to the potting trade. I have worked along with the development of mine and mill in order to make sure that the clay was properly mined, washed and prepared and maintained up to quality.

In spite of all instructions and counsel regarding the necessity of maintaining a standard of selection and a standard of washing, and sticking to it, in no case have I ever found where this was continuously followed. On the other hand the superintendent or manager of the plant would do what he thought wisest or best at the particular time a problem would arise, regardless of the ultimate outcome. These managers or superintendents are not as a rule acquainted with how the clay is used nor are they familiar with pottery practice.

One plant I have in mind at this time had all the necessary capital and had built one of the finest plants in the country and were actually in a position to turn out a very fine product. The mill was well equipped and well supplied with the proper facilities and knowledge to do good work. Careful instructions were given regarding the necessity of the selection of the clay, the milling

and mining, and every detail. A cut and dried program was established so that the very best results could be obtained in the shortest period of time. The work should have progressed as planned. After one month I returned to the mine to find the superintendent had rearranged his own program and was doing things as he thought they should be done, but which proved to be the reverse of good practice. In other words, he used his judgment in the selection of the clays and in the washing, and was turning out a product far from satisfactory, and which would not be, nor ever could be, satisfactory to the potter.

Many instances of such ill-advised work could be cited. In some of the American mines the endeavor seems to be to work into the clay as much refuse material as possible, thinking perhaps that it will not be noticed.

The American miner is optimistic—far more so than he should be, and then adds carelessness to his work not intentionally perhaps, but because he does not understand clay values, or is ignorant of the principles of true applied carefulness, or is blind to his own faults. It is not possible, and never will be possible, to turn out any good American clay for white ware on the working basis that has existed in the clay mining trade of this country in the past. It seems impossible to make the miner realize the necessity of most careful selection to say nothing of the delicate methods of handling during the washing process. And no American product is going to succeed until these things are more fully appreciated.

Had we in America today exactly the same type of primary clay deposit that they have in England, we ourselves could not compete with English quality if the same apparently thoughtless and careless methods of mining and washing were pursued as now exist.

There are combinations of various American clays which have been proven to yield satisfactory American ceramic products, but with few exceptions the potteries have lacked confidence in the ability of the miner to produce his product carefully, conscientiously, and above all, uniformly.

CERAMIC ABSTRACTS[1]

General

A promising tunnel oven. STAFF ARTICLE. *Pottery Gaz.*, **45**, 1208–11 (1920).—The Marlow oven takes the form of a long, brick-built tunnel which can be so adjusted in length, height, and width to suit the particular local circumstances of any factory, large or small, at which it may be decided to install it. One operating at the Patent Tile Works, Stoke, Eng. is 150 ft. long, 7 ft. 6 in. from floor to crown and 8 ft. 6 in. at the base. Through the tunnel runs a railway along which the ware to be fired is passed. The train of trucks are driven through the tunnel by a motor which drives a reduction gear. One truck is drawn every hr. and the tunnel holds in all 30 trucks, which is equal to 30 hrs. from the time of feeding to the time of drawing. Eight trucks are filled and 8 trucks drawn by each shift of workers. Tile were fired in the kiln described but most any class of pottery may be fired in this kiln. Although the use of saggers has not been eliminated, they are retained as a convenience rather than a necessity. They have proved handy for lifting tile on and off the trucks. Each sagger contains 40 tiles and it is possible to place 33 saggers on each truck, which is equal to about 25 sq. yds. of tile per hr.—day and night. The wear on saggers in the tunnel kilns is comparatively small since the saggers support only a small load as compared with those used in the intermittent kiln where the bungs are often 17 high. Saggers were not used in one case in burning domestic ware, and the ware was perfectly fired without showing signs of sulphuring. This is due to the fact that perfect combustion is obtained by a special method of firing. The system is that of direct gas firing by a method of superheating, in which both gas and air required are heated to a high temp. before combustion. The air is brought in at the ingoing end of tunnel, taken through the firing zone and afterwards brought back and used in the combustion chamber. The three essentials for gas firing are (1) the producer shall be so constructed as to give a regular flow of gas, (2) the recuperation or superheating of the air shall be of such a nature that the air comes into contact with the gas at a temp. very nearly as high as that of the firing zone, and (3) the exhaust which really governs the whole procedure, must be so arranged as to exert a uniformly distributed pull, capable of drawing from all parts of the oven at the same speed. The temps. of given sections of the tunnel can be raised or lowered at will by merely opening or closing of dampers and regulating the influx of gas and air respectively. It has been possible within a space of 9 hrs.

[1] The abbreviation (C. A.) at the end of an abstract indicates that the abstract was secured from the Editor of Chemical Abstracts by coöperative agreement.

to fire successively 3 trucks of ware to a temp. of 1165° C; 3 trucks to 1040° C, reverting during the last 3 hrs. to the previous temp. The exhaust by means of which the sulphurous vapors are removed is remarkable. The exhaust is constructed at the level at which the heated gases are required to be drawn. The arrangement consists of a system of pipes, through which an even pull is exerted by a fan placed in the hovel of a disused oven. Sections of the exhaust if necessary, can be placed at different parts of the tunnel, so that by means of a damper fixed in an overhead flue, any of the exhaust sections can be used separately, an arrangement which makes it possible to lengthen or shorten the soaking zone when required. The exhaust is so perfect that a chimney stack is not necessary. H. G. SCHURECHT.

Pyrites in clay. J. SCOTT. *Brit. Clayworker*, **29**, 167–8 (1920).—Common pyrites frequently contains small quantities of copper, arsenic, tin and other metals, the existance of which complicates their chem. reaction with other materials. In firing brick containing pyrites, the S is eliminated and changed to H_2SO_3. The remaining Fe fuses to black lumps. Pyrites is more likely to be a nuisance than a benefit to clays. H. G. SCHURECHT.

The binary system, akermanite-gehlenite. J. B. FERGUSON AND A. F. BUDDINGTON. *Amer. Journ. Sci.*, (4) **50**, 131–40 (1920).—The binary system åkermanite ($2CaO.MgO.2SiO_2$)-gehlenite ($2CaO.Al_2O_3.SiO_2$) was studied by the quenching method and the solidus and liquidus curves determined. The system forms a complete series of solid solutions with a minimum melting point about 70° below the melting point of åkermanite, the component of lower melting point, at a composition of about 74 per cent åkermanite and 26 per cent gehlenite.

The densities of crystals and glasses of åkermanite, gehlenite, and several intermediate mixtures were determined and found to confirm the isomorphous character of the system. Åkermanite was found to show the unusual feature of its glass having a greater density than the corresponding crystals at 25° C. This peculiar character is checked by the indices of refraction, respectively for glass and crystal, the index of refraction of the glass being greater than the maximum index of the crystal.

The optical characters of the crystals are a continuous function of the composition. Åkermanite is positive in its optical characters and gehlenite is negative. Crystals of certain intermediate compositions are isotropic for light of a definite wave length and constitute a transition phase between positive and negative crystals.

Vogt has discussed the relations of åkermanite and gehlenite as interpreted from a study of slags. He concluded that they mix to form an isomorphous series, and found that the birefringence of intermediate mixtures decreases to 0. However, the formulas assumed by Vogt for åkermanite and gehlenite differ from those used by the authors, and most of his materials contained iron, manganese, soda, or other impurities, so that the data he obtained are the result of more complex mixtures than the system discussed in this article.

ROBERT B. SOSMAN.

New facts about surface friction. CH. TERZAGHI. *Phys. Rev.*, **16**, 54–61 (1920).—These investigations are preliminary to the study of the physical properties of clays. A study was made of the smooth glass plates in order to determine the laws governing the frictional forces. The frictional resistances are due to the existence of microscopic particles thatdeposit themselves upon the rubbing surfaces and not into the shearing strength of air or water. Evaporation of a drop of water placed between two plates ceased when the thickness of the film was about 100 mm, which indicates that molecules of a solid exert force over a distance of about 50 mm. Viscosity, shear and tensile strength are involved in the action of such thin films of water. The author uses these results to explain the facts (1) that clay layers are impermeable unless the heat exceeds a certain minimum; (2) that the water contents of clays do not drop below certain limits. T. concludes that the ordinary loss of friction of rest apply only where contact between the rubbing surfaces must be enforced by outside pressure. When two even surfaces are in contact the explanation of the cause of friction is not so simple on account of the presence of small particles on the surface. A. J. LAMBERT.

Magnesite in New Mexico. ANON. *Min. Sci. Press*, p. 422, (1920); *Eng. Min. Jour.*, **110**, 673.—A small deposit of magnesite, having no commercial value, and lying 30 miles north of Lordsburg, N. Mex., was recently examined by R. W. Stone of the U. S. G. S. D. D. SMYTHE.

Purifying clays by electrical osmosis. J. S. HIGHFIELD, DR. W. R. ORMANDY AND D. NORTHALL-LAURIE. *Mining Magazine*, **23**, 113–4.—Gives a general discussion of electrical osmosis and then proceeds to discuss the separation of pyrite, silica, and mica from clay by this method. The process has a wide range of application to different varieties of clays, the cost varying likewise. D. D. SMYTHE.

Talc in South Africa. T. G. TREVOR. *Mining Magazine*, **23**, 185–6.—The Scotia talc mine has recently been opened in the Barberton District, South Africa. The talc lies in a series of beds 400 feet thick. Development work has proved that there is enough talc to warrant the establishment of a permanent industry, and that the talc can be mined and hoisted for a few shillings a ton. A mill capable of handling 500 tons a month has been installed and is now in operation. D. D. SMYTHE.

Science of powdered-fuel combustion. JOSEPH F. SHADGEN. *Iron Age*, **106**, 457–61 (1920); cf. *C. A.*, **14**, 1028.—A preliminary general discussion of heat is accompanied by tables illustrative of (1) vol. of air required for the complete combustion of a given coal; (2) influence of excess air on analyses of waste gases; (3) theoretical temp. of combustion with various air quantities, and (4) influence of preheated air. The effects of moisture and of pulverization are sketched. While formerly an av. of 25 per cent to 35 per cent volatile matter was usually recommended, today, as a result of improved design,

all grades of solid fuel—lignite, sub-bituminous, anthracite culm, or coke breeze—are successfully burned in powder form. The coking quality of a coal is practically without significance. Ash, however, presents a considerable problem. The effort expended in grinding and transporting it is lost; the heat absorbed to raise its temp. is lost; very serious accumulations may result; dangers of slags and fluxes that destroy walls and roof arches are introduced. The ash should be sepd. before burning and the attempt to eliminate it should be made after pulverization. With regard to furnaces necessitating Siemens regenerative chambers, it is thought that an ash content of 1 per cent to 2 per cent will reduce all troubles to an acceptable practical minimum. [*C. A.*]

PATENTS

Method and means for firing tunnel-kilns. JOHN B. OWENS. U. S. 1,355,906, Oct. 19, 1920. A tunnel kiln having a combustion chamber communicating at its side with the interior of the tunnel and provided with means for deflecting from the chamber into the tunnel the heat and products of combustion developed within the chamber, and means for firing the combustion chamber in the direction of its length.

Firing means for tunnel-kilns. JOHN B. OWENS. U. S. 1,356,397, Oct. 19, 1920. A tunnel kiln having a multiple firing or burning zone, with combustion chambers communicating with the firing zone at different points of the combustion chambers in a direction other than toward their communication with the firing zone. The chambers have means to directly and initially deliver the heat and products of combustion derived from firing onto the lower portions of the ware in the tunnel. The chambers maintain the multiple firing zone for the purpose of subjecting the goods or ware to a relatively long "soaking" heat at the temperatures necessary to burn the same. The kiln is provided with draft means adapted to cause the heat and products of combustion to directly flow from the chambers into the tunnel and in the same direction through the multiple firing zone after first striking the lower portions of the ware.

Tunnel-kiln. PHILIP DRESSLER. U. S. 1,354,541, Oct. 5, 1920. A tunnel with combustion chambers arranged on each side of the interior of the inclosing structure, the combustion chambers each divided into two sections connected by a sleeve which permits relative movement between such sections, together with means for introducing gas and highly heated air into one section of each chamber and projecting it longitudinally into the adjacent section of the chamber.

Continuous tunnel-kiln. PAUL A. MEEHAN. U. S. 1,355,407, Oct. 12, 1920. A continuous kiln of the tunnel type, with an elongated kiln chamber comprising two sections meeting at an angle and a turntable within the kiln chamber at the junction of the sections for receiving a goods carrying car approaching the table from one section and rotating it into alignment with the other section.

Multiplex tunnel kiln. JOHN B. OWENS. U. S. 1,356,398, Oct. 19, 1920. Describes a car tunnel kiln having a closed partition rising between the car platform and extending lengthwise through the kiln between the sets of tracks, the walls of the kiln being imperforate where they face the partition. Means are provided for sealing those parts of the tunnel which are below the cars from those parts which are above the cars, whereby the partition and the ware or clay products on the cars define a longitudinal flue in the kiln compelling the passage of the heat and products or combustion lengthwise through the tunnel of the kiln.

Method of firing tunnel-kilns and convertible furnace therefor. JOHN B. OWENS. U. S. 1,356,396, Oct. 19, 1920. A kiln in which the ware is burned, having a combustion chamber opening into the burning chamber, and means for directing heat into the combustion chamber from any one of a plurality of independent sources of fuel differing in kind and extraneous to the combustion chamber. C. M. SAEGER, JR.

Refractories

Refractories for electric furnaces. ANON. *Chem. Met. Eng.*, **23**, 769–70. —Report of symposium on refractories for electric furnaces held by the Electric Furnace Association in Columbus on October 6, 1920. The ideal refractory for electric furnaces should have a melting point higher than 1750° C; should be highly resistant to sudden temperature variation so as to permit intermittent operation; should be constant in volume at high temperatures; should resist the scar of slag and should withstand the action of fumes, hot gases and molten metals; should be a poor conductor of electricity and should have considerable mechanical strength at high temperatures. When fire clay brick are used in electric furnace side walls, unless the walls are very thin and radiate heat very rapidly, the inner surfaces melt down very quickly or soften and absorb quantities of slag and metal from the bath. Silica brick, up to the present, have given best service in roof arches. They melt at about the same temperature as good fire clay brick but retain their shape and much of their strength to a high temperature. They must be heated or cooled at a very low rate and thus are not suitable for intermittently operated furnaces. Magnesite brick are most commonly used for basic linings. Carborundum brick have been used to some extent for door jams and roofs. Among possible refractory materials to be considered are alundum, sillimanite mixtures, magnesia spinel, zirconium oxide, zirconium silicate, and fused magnesia. A. J. LAMBERT.

Refractory materials for chemical purposes. A. B. SEARLE. *Chem. Age (London)*, **2**, 684–50; **3**, 123–4 (1920).—Resistance to pressure at high temperatures can be secured by using compositions that are essentially one chemical compound. Mixtures of compounds soften below their ultimate melting point due to the formation of eutectics. Vitrification gives resistance to corrosion and abrasion, but usually increases tendency to spall. For re-

sistance to corrosion by liquids and gases, an impervious structure is more important than chemical composition. Numerous large scale tests have shown that silica and fire clay brick may be used advantageously in steel furnaces in which a highly basic (calcareous) slag is produced provided that the bricks are sufficiently impervious to present a minimum area to the corrosive action of the slag. If porous bricks are used, rapid corrosion occurs. The use of magnesite brick in contact with acid slags is less satisfactory because the texture of the bricks is coarse and more favorable to chemical corrosion. The action of acid slags on a mass of fused magnesia is scarcely appreciable, but if the magnesia is reduced to a coarse powder it is rapidly dissolved by the slag. E. T. RODGERS.

Preparation of magnesium oxide. ANON. Bur. Standards Tech. News, *Bull.* **43** (1920).—Magnesium oxide is packed about a small carbon rod between two large carbon electrodes set in the end of a box-like concrete shell lined with zircite. The electric current first heats the small carbon rod to a temperature which fuses the magnesium oxide with which it is surrounded. This fused magnesium oxide then has greater conductivity and the cross-section of this core of the fused material gradually increases to the end of the run. A run in one small furnace takes about 30 minutes and a fused core of about 15 to 20 lbs. of pure magnesium oxide is produced. E. T. R.

A new method for the determination of zirconium. MELVIN M. SMITH AND C. JONES. *J. Am. Chem. Soc.*, **42**, 1764–70(1920).—The only reliable method, *viz.*, "cupferron," for the quant. detn. of Zr is impracticable commercially because of its cost and its lack of simplicity with other elements present. The new method is based on the pptn. of basic selenite by H_2SeO_3 in acid (HCl) soln. Comparative tests by the cupferron method with known solns. showed the new method to be thoroughly accurate, the greatest difference between the two being 0.3 per cent. Free H_2SO_4 should not be present and the soln. should not contain over 7 per cent concd. HCl. The selenite ppt. is sol. in 10 per cent free acid, but pptn. from 7 per cent HCl gives no loss of Zr. Detailed procedure is given for prepn. of H_2SeO_3 and for sepn. of Zr from Al, Fe, Ti, H_3PO_4 and the rare earths. To det. Zr in ore fuse it with 10 wt. of KHF_2 to a clear liquid, treat with 1 : 1 H_2SO_4 and heat to fuming. Boil the residue with H_2O and dil. Ppt. with NH_4OH (NH_4Cl present), wash the ppt., dissolve in HCl, dil., and ppt. with H_2SeO_3. Filter off the insol. basic selenite, wash with 3 per cent HC_4, and ignite to ZrO_2. [*C. A.*]

PATENTS

Combination of matter for fire-bricks and refractory linings. ARTHUR F. QUIN. U. S. 1,355,689, Oct. 12, 1920. A refractory composition comprising mica, asbestos and salt ground and mixed.

Refractory material. JOHN A. OHMAN. U. S. 1,356,939, Oct. 26, 1920. A non-recrystallized refractory material for heat resisting articles comprising silicon carbide and crystalline graphite. C. M. SAEGER, JR.

Glass

"The influence of strain on the properties of optical glass." J. BERNDT. *Zeits. fur Instknde.*, Jan., 1920, *et seq.*—(1) Annealed sections cut from plate glass possessed a somewhat higher value for compression and tensile strength test than unannealed rods. Higher values were obtained for annealed material if the test pieces in their final condition are made strain free. The cross bending strength is greater for strained pieces. It is essential to carry out experiments on well annealed pieces because deviations up to 25 per cent may be caused by strain. The assumption of Schott regarding a compression layer formed by air cooling is only justified for articles not to be subjected to further working. Greater strength results from good annealing if the compression layer is to be cut through or if pieces are to be subjected to cutting or grinding, as in optical work. The scratch test shows the same value for strained and for annealed glass. (2) *The influence of strain on the modulus of elasticity.* Quincke found that for a fiber of flint glass the modulus of elasticity increased about twice on standing for six months and that it was four times smaller in strained pieces. The values of Winkelmann and Schott are: Strained 754,300 Kg/mm² annealed 750,900 Kg/mm², Ludwig found: strained 700,000, annealed 600,000. For a boro-silicate crown, strained 814,600, annealed 755,700 showing an increase of 7.8 per cent. Annealing always causes an increase of about 8 per cent. Quincke's result is attributed to his method of observation. Kundt's figures were used. (3) *Refraction and density.* On density no quantitative references were found except these of Schott who stated that the removal of strain was accompanied by a decrease in volume and an increase in density.

Refractive Index. J. O. Reed. The index was increased on annealing.

Designation of glass	N_D.	Temp. °	Changes in 5th deci. place
S 57	1.96243	299	—81
S 163	1.89033	364	—17
O 165	0.75448	408	—14
O 211	1.57270	406	0
O 527	1.57170	406	0
O 154	1.57089	452	—93
O 1299	1.60982	404	+1
O 1805	1.51754	411	0
O 1805	1.51828	...	—27

Reed: glass from optical pots differ as much as 15 to 93 units in 5th decimal place. Samples from the same plate show 25 in 5th place. Samples from same melt but not from same plate show two in 3rd place, but in these experiments part of their difference can be attributed to strain. In the same prism influences of inhomogeneity are eliminated and here differences of 3 units in 3rd place can be caused by strain. Strained 6385, annealed 6438,

difference 0.8 per cent. (4) *Specific refractivity.* Certain types of glasses are almost in agreement with Newton's formulas $(n^2 - 1)/d$. $(n - 1)/d$ is correct to about 0.1 per cent. The Lorenz-Lorentz formula is correct to plus 0.2 per cent to —1.8 per cent, Newton's to —0.3 per cent plus 0.07 per cent. (5) *Influence of strain on the expansion of optical glasses.* Schotts' observation on short cylinders gave a variation of 5 per cent to 15 per cent on annealing. Berndt cites one glass in which the expansion increased 17 per cent in the strained condition. A decrease of 5 per cent in barium crown glass was observed on annealing. (6) *The applicability of Hooke's law to glass.* The cross section was 2 to 5 mm. and the sample was loaded to fracture. Hooke's law held up to the point of fracture within 1 per cent. Permanent deformation was not shown in the short interval of time used. *Summary.* The strength of plate glass: Compression strength, 12400 average, 13800 maximum, Kg/Cm²; tensile strength, 710 average, 760 maximum; transverse strength, 920 average, 980 maximum. Strength of boro-silicate, 516/680, annealed. Compression strength, 18,100 ave., 20,900 max.; tensile strength, 690 ave., 870 max.; transverse strength, 1080 ave., 1120 max.; scratching hardness, 55.3; modulus of elasticity, 814,600. By strong strains the density of glass is decreased by 0.8 per cent and the refractive index by 2.2 per cent. Therefore, the γ value is constant to less than 0.1 per cent. If a compression layer is present the expansion coefficient increases with increasing temperature. The forces exerted by strain give value of about 2000 Kg/Cm² which effects a diminuation in length of maximum of 0.3 mm. per 100 meters of length. Generally an increase of density takes place of about 2 in. 2nd decimal on annealing and the refractive index changes by about 3 in 3rd place. WM. M. CLARK.

The absorption of heat in glass. A. Q. TOOL AND C. G. EICHLIN. *Journ. Opt. Soc. Am.* **4**, 340–63 (1920).—Glass, on being heated, exhibits within a definite and narrow temperature range a marked increase in heat absorption. This may be caused by one or more types of molecular aggregates, which may have a crystalline structure, Chilling or annealing glass produces the effect that should be expected if the absorption of heat on heating and its evolution on cooling are due to the formation and dissolution of some such crystaline structure or other molecular aggregate. It is possible that certain methods of cooling or treatment may cause structural inhomogeneity in glass through the non-uniform formation of these aggregates. E. T. RODGERS.

Cause of blisters in glassware. T. D. LONG. *Glassworker*, **39**, 18 (1920). —Blisters are caused by vacuum due to cooling too long. An experiment is described to prove this. A gathered piece held in a stream of compressed air will form blisters on the inside. On heating in a glory hole they will disappear and will not reform on cooling if the cooling is properly done. R. J. M.

Glass container research. work J. M. HAMMER. *Glassworker*, **40**, 11 (1920).—A general description of the work being done by Dr. A. W. Bitting in the laboratory of the Glass Container Association of America. R. J. M.

Glass colors. *Schnurpfeil's Review for Glass Works*, **4**, 685 (1920).—The normal color for the ordinary coloring oxides in various kinds of glass is given:

Metal oxide	Lead glass	Potash glass	Soda glass
Silver oxide	.....	Yellow or orange	Yellow or orange
Chrome oxide	Greenish red	Greenish yellow	Grass green
Cobalt oxide	Pure blue	Blue	Bluish violet
Copper oxide (red oxide)	Blood red	Purple	Purple (yellowish)
Copper oxide	Green	Sky blue	Sky blue (greenish)
Ferrous oxide	Greenish yellow	Bluish green	Bluish green
Iron oxide	Greenish yellow	Bottle green	Bottle green
Manganese oxide	Amethyst	Bluish violet	Reddish violet
Nickel oxide	Bluish violet	Amethyst	Yellowish violet
Purple precipitate of cassius (gold)	Red or rose	Red or rose	Reddish blue
Uranium oxide	Topaz	Siskin yellow	Greenish yellow
Sulphur, carbon	Black	Golden yellow	Pale yellow
Antimony oxide	Orange (opaque)	.....	.....
Selenium	.....	Pink	Salmon color
Tin oxide	Enamel white	White	White

R. J. MONTGOMRY.

Alabaster glasses using talcum. *Schnurpfeil's Review for Glass Works*, **4**, 685 (1920).—No. 1—Sand 100, soda ash 35.5, lime 10, saltpetre 5, talcum 16.5, fluorspar 3. No. 2—Sand 100, soda ash 38.5, lime 8, talcum 14.5, fluorspar 4, arsenic 0.5. No. 3—Sand 100, soda ash 36, lime 8, talcum 20, saltpetre 8. Talcum (soapstone, steatite) is used for opacifying glasses. It contains silicate of magnesia and makes the glass refractory. R. J. M.

Composition of chemical glass. *Schnurpfeil's Review for Glass Works*, **4**, 687 (1920).—Sand 100, soda ash 35, lime 18, borax, 4, alumina 8, manganese 0.25, arsenic 0.25. R. J. MONTGOMERY.

Composition of Bavarian plate glass. *Schnurpfeil's Review for Glass Works*, **4**, 687 (1920).—Blown plate glass: No. 1—white sand 1000, potash 175, soda ash 180, lime 250, manganese 2, arsenic 2; No. 2—white sand 1000, soda ash 340, lime 260, saltpetre 10, arsenic 5, manganese 1. R. J. M.

Composition of cheap watch glass. *Schnurpfeil's Review for Glass Works*, **4**, 687 (1920).—Sand 100, soda ash 33, lime 10, barytes 5, lead 3, saltpetre 2, arsenic 0.5, manganese 0.2, nickel oxide 0.001. R. J. MONTGOMERY.

A note on the annealing of optical glass. L. H. ADAMS AND E. D. WILLIAMSON. *J. Optical Soc. Amer.*, **4**, 213–23 (1920).—The old method of annealing optical glass consisted of heating the glass rather slowly to a maximum temperature and then cooling it gradually from that temperature

The authors recommend a new method in which the glass is heated very rapidly to a rather low annealing temperature, is held for some hours at that temperature and is then cooled at a rapidly increasing rate. A. J. LAMBERT.

A method for determining the annealing temperature of glass. J. T. LITTLETON AND E. H. ROBERTS. *J. Optical Amer.*, **4**, 224–9(1920).—A glass cane, ten centimeters long and four to five millimeters in diameter, was sealed between two larger pieces of cane of one centimeter diameter, the ends of which were held in chucks. One chuck was centered on the axis of a ball-bearing pulley wheel, the other to a universal joint. The temperature of the furnace in which the glass was heated was raised at the rate of one or two degrees per minute. This rate could probably be increased. The pulley wheel was loaded at the rim so that a shearing stress of 4 kg/mm^2 was given to the glass. After the rod was inserted in the furnace the load was applied and the position noted of a spot of light reflected from a concave mirror attached to the axis of the wheel and focussed on a scale two meter distant. The rate of motion of this spot was taken as a measure of the fluidity of the glass. The recording of the position of this spot and the temperature of the furnace at various intervals gave values from which a viscosity curve was obtained. This determined the rate of rotation at 550° C for standard glass to be 16 cm per minute or an angular rotation of 5° 32′ per minute. Hence to obtain the annealing temperature of any glass, the above experiment is repeated on the glass and the temperature which gives a scale deflection of sixteen centimeters per minute is the annealing temperature of the glass. The slope of the curve obtained by plotting the logarithm of the fluidity against the temperature is a measure of the rate of viscosity change for the deflection is determined as above, using the same units and rods of the same dimensions, gives a temperature at which the glass takes on very little permanent strain when cooled at any ordinary rate. At this temperature the glass anneals in about sixteen hours. The maximum temperature to which it is safe to heat a glass may be determined by practical tests on the standard glass in the form of ware commonly used. Having determined the maximum temperature, the point on the fluidity curve at that temperature gives a measure of the maximum allowable fluidity. Therefore any glass of a fluidity equal to this standard is at the maximum safe temperature. Using these methods the following min. and max. values were obtained for various Corning glasses:

Glass type	Annealing point ° C	Straining point ° C
Borosilicates	518	470
	550	503
Limes	472	412
	523	472
Leads	419	364
	451	382

A. J. LAMBERT.

The melting of colored glasses. ANON. *Glasindustrie*, **31**, 209–10 (1920).—An alkali mix is the usual basis of colored glasses. The chemical composition, the nature of the coloring oxides and the furnace operation must all be carefully watched. The yellows are very difficult to produce. Twenty formulas for yellow glass are given, 10 for blue, 32 for green, 2 for gold-ruby, 2 for copper-ruby, 2 for gray, 2 for black and 2 for brown. C. H. KERR.

Ultramarine blue. DR. ING SPRINGER. *Die Glashutte*, No. **33**, Aug. (1920).—Ultramarine blue is an aluminous silicate containing sulphur, easily dissociated with simultaneous disappearance of color so that it produces in glass fusions a yellow or brownish color instead of blue. Experiment was tried of adding 5 parts ultramarine blue to 100 parts sand in a high soda-lime-glass batch in a laboratory furnace. Shortly after heating at a low temperature the blue color of the frit disappeared and same became light yellow; then when heated strongly to fusion the yellow color disappeared and the glass became of a light bluish tinge so that a partial reformation of ultramarine is conceivable as has been previously observed (unless the high iron content may have been responsible for the color). A second experiment was tried adding 10 parts ultramarine to 100 parts sand and after fusion resulted in a strong yellowish red, sulphur-ruby colored glass of very beautiful and evenly distributed characteristics. It is possible that ultramarine is well adapted to the formation of orange and sulphur rubies. WM. M. CLARK.

Optical glass and its future as an American industry. ARTHUR L. DAY. *Jour. Frank. Inst.*, **190**, 453–72 (1920).—The future of the industry must remain vague. Three firms entered this field, to produce optical glass on a large scale for war purposes, of whom two were able to make use of the product in instruments of their own manufacture. This portion of the industry may endure in whole or in part. The third successful producer of optical glass has to find his market outside his own plant, and this market is rather too intangible to be attractive as a business venture. The cost of several of the necessary ingredients is necessarily greater in this country than in European countries where similar products originate. In quality our raw materials are equally good, our experience in technique is adequate if not equally extensive with some of our European contemporaries, but the cost of potash, for example, will always lay a burden upon the American product, and other ingredients might be mentioned which fall in the same category. If there were a market sufficient to stimulate production on a very large scale these difficulties could be overcome by improved technique and organization, as in the case of other conspicuous American industries, but the demand for optical glass will probably never be large, and the incentive to large-scale processes and cheaper production will therefore probably always be lacking unless the Goverment determines upon a definite program of preparedness. The instrument maker may find it advantageous to make his own glass for the reason that he can then arrange for the precise optical constants which he wishes to use in his instrument, and he may have them within a period of a few days instead of

weeks or months, but the trade itself will perhaps never furnish sufficient incentive to build up a large industry in this country. Successful makers of optical glass in other countries have had to look for their profit in other lines rather than in their optical products. A. J. LAMBERT.

PATENTS

Manufacture of window glass. CLYDE S. ROBB. U. S. 1,356,739, Oct. 26, 1920. The manufacture of window glass cylinders with the operation of upward drawing from a molten bath and simultaneously effecting a twisting of the cylinder wall between the bath and the cylinder in formation.

Wire-glass. VICTOR SHUMAN. U. S. 1,355,625, Oct. 12, 1920. A fire resisting body, comprising a sheet of wire-glass, a sheet of plate glass, and an interposed layer of organic material.

Cutter or gripper for use in drawing sheet-glass. HUDSON D. CAMPBELL. U. S. 1,355,449, Oct. 12, 1920. A cutter and gripper formed of carbon for use in connection with the drawing of sheets of glass.

Means for transferring glass to molds. LEONARD D. SOUBIER. U. S. 1,356,174, Oct. 19, 1920. An apparatus with means to supply a stream of molten glass with a traveling mold, a transfer cup traveling therewith, and the means to shift the cup from a position beneath the stream of glass to a position over the mold and discharge the glass into the mold.
C. M. SAEGER, JR.

Glass manufacture. CORNING GLASS WORKS. Brit. 145,428, June 17, 1920. Relates to the compn. of glass specially suitable, as regards expansion, viscosity at working temps., and resistance to devitrification, for the manuf. of elec. lamp bulbs. According to the invention, the glass contains the following constituents in the proportions stated, *viz.*: SiO_2 100 molecules, Na_2O 20–36 molecules, and at least one of bivalent alk. earth oxides 6–36 molecules. The specification gives 9 batch formulas by way of example, the fifth being as follows: SiO_2 100 mols. (or 63 per cent), Na_2O, 25.5 mols. (22.2 per cent); MgO 7.7 mols. (6.2 per cent), and CaO 7.9 mols. (8.8 per cent). C. A.

Furnace for manufacturing glass. K. HAYASHI AND K. OKADA. Jap. 35,595, Dec. 27, 1919. C. A.

Whiteware and Porcelain

The lead question in ceramic industries. L. PETRIK. *Sprechsaal*, **53**, 405–8 (1920).—When alkalies or borax are used in lead glaze frits they make the same soluble. Lead frits containing no alkalies or borax on the other hand are insoluble. Soluble lead frits are dangerous in causing lead poisoning among potters. By making two frits, one containing all of the lead oxide with no alkalies or boric acid and another containing all of the alkalies and

boric acid, the amount of soluble lead oxide is greatly reduced. P. recalculated a number of commercial glaze frits preparing a high lead and a high alkali frit in the place of the poisonous alkali-lead frit.

Two high lead frits were used of the following composition:

Frit. No. VII—0.774 PbO 0.055 CaO 0.044 K_2O 0.127 Na_2O	0.134 Al_2O_3. 2.374 SiO_2
Frit No. XII—0.75 PbO 0.20 CaO 0.05 K_2O	0.12 Al_2O_3. 2.4 SiO_2

Frit. no. VII, of which dil. HCl dissolves 1.0 per cent lead oxide, was used for the preparation of low melting glazes and frit no. XII, of which dil. HCl dissolves 0.55–0.60 per cent lead oxide, is used for the preparation of the higher maturing glazes. Using combinations of these frits the soluble lead oxide was decreased from 31.7 per cent to 0.76 per cent in one glaze, from 23.05 per cent to 0.3 per cent in a second, and in another from 20.72 per cent to 0.25 per cent. Pandermit (natural calcium borate) may be used in the place of the leadless frit. By preparing a tin glaze by the use of the two frits given above, the percentage of soluble lead oxide was reduced from 4.18 to 1.03 per cent. The presence of CaO reduces the solubility of frits. The amount of lead oxide soluble in dil. acid according to Thorpe's method should be less than 1.00 per cent. H. SCHURECHT.

Frits for whiteware glazes. ANON. Bur. Standards, Tech. News *Bull.* No. **43** (1920).—A special investigation has been undertaken of various mixtures of feldspar, boric acid, and whiting to determine the most satisfactory mixture of these materials for use in white ware frits and also to discover the most economical and efficient method of the manufacture of such frits. E. T. RODGERS.

PATENTS

Porcelain cement. PORZELLANFABRIK KAHLA. Brit. 145,026, June 14, 1920. A substance having a smaller coeff. of expansion than porcelain, *e. g.*, quartz glass, is added to cement to produce a compn. for cementing porcelain. C. A.

Enamels

The fish scaling of ground coat enamels. ANON. Bur. Standards, Tech. News *Bull.* No. **43** (1920).—The study of the cause and control of fish scaling of ground coat enamels has been continued, by the preparation of two series with a total of 14 enamels, in one series the felspar being high, while in the other the quartz is high. In each series the fluxes are varied in a systematic manner. The results obtained thus far agree with those for gray ware

enamels, that is, the constituents which tend to promote or retard fish scaling has the same results in the two types of enamels. Furthermore, it was found that there was little tendency to fish scale in three-coat enamels applied to low copper steels which agrees with the results obtained with one-coat enamels. The determinations of the thermal expansion of various types of enamels used for coating sheet steel are being continued.

E. T. RODGERS.

Artificial cryolites. ANON. *Z. angew. Chem.*, **33**, I, 200 (1920).—Description of patent granted the firm of J. L. Eckelt. HF is drawn from the vessel in which it is generated by a water-jet vacuum-pump actuated by a soln. of Na_3AlO_3. The cryolite separates as a fine cryst. powder which does not clog the pump. The advantages of the method are: Attainment of the end-product by two manipulations (the fusion of kaolin and soda and the action of HF on these); great simplification of equipment and decrease of attendant costs; no escape of HF from the app. and hence plants can be erected in cities. *C. A.*

Brick and Tile

Clays for hollow block. ANON. *Brit. Clayworker*, **29**, 169–70 (1920).—Hollow block are increasing in popularity because they are easily produced, are relatively cheaper, cost less for transportation and are much more rapidly laid than solid brick. Hollow block should be (1) hard, (2) impermeable to water, (3) strong and (4) correct in shape. To secure these qualities the clays used must vitrify at comparatively low temps. without losing their shape, so a clay high in lime would be undesirable. Shales and low grade fire clays are usually satisfactory since they contain more desirable fluxes. An economical temp. to fire block is cone 1A, 1100° C. H. G. SCHURECHT.

PATENTS

Apparatus for burning brick. WILLIAM W. DICKINSON, JR. U. S. 1,355,821, Oct. 19, 1920. A number of brick kilns each having its interior part of bricks loosely piled and formed with eyes or arches, and having its top and sides formed of bricks closely piled. One of the sides of each kiln is formed with a vertical passage way which communicates at its upper end with the interior of the kiln adjacent to its top and is formed at its lower end with an opening and a movable conduit adapted to connect the opening with the eyes or arches of the succeeding kiln. C. M. SAEGER, JR.

Cement and Lime

The manufacture of lime for chemical and metallurgical purposes. I. RICHARD K. MEADE. *Chem. Met. Eng.*, **23**, 841–4 (1920).—Kilns employed for burning lime are intermittent, pot, rotary and shaft. The shaft may be of a mixed feed or separate feed type. Intermittent kilns are primitive, uneconomical and seldom used except for burning lime for the farm. In the

mixed feed shaft kiln, the fuel is mixed with the limestone to be burned. In the separate feed shaft kiln the fuel is burned in fire boxes in the base of the shaft. The mixed feed kiln is more economical of fuel but gives a product contaminated with ashes and therefore the separate feed type is preferred for better grade lime. A shaft kiln commonly consists of steel cylinders lined with fire-brick. A few kilns have been built with reinforced concrete taking the place of the steel cylinders and have proven satisfactory. A strong draft is requisite for burning lime. The most satisfactory method is the use of induced draft but forced draft is employed in some cases. One ton of good bituminous coal hand fired will burn from $3^1/_2$ to 4 tons of lime. The same fuel used in a gas producer will burn from $3^1/_2$ to 5 tons. One barrel of fuel oil will burn from 1 to $1^1/_4$ tons of lime. One cord of seasoned hard wood will burn from $2^1/_2$ to $2^3/_4$ tons. A. J. LAMBERT.

The effects of Cal as an accelerator of the hardening of portland cement mixtures. ROY N. YOUNG. *Tech. Paper*, Bur. Standards, No. 174.—Cal is essentially an oxychloride of lime in a powdered form. It is readily decomposed by water into calcium chloride and calcium hydroxide, the property of accelerating the hardening of portland cement, being due to the former product. The chief advantage of using Cal rather than calcium chloride is the much greater convenience with which it may be handled.

The setting-time of portland cement mixtures was hastened by the addition of Cal to an extent which is considered very desirable in certain types of concrete construction, especially floor toppings, for the reason that the finishing operation may proceed with much less delay. Tests on quick-setting cements indicate that such cements may be made normal by the addition of Cal. It is also shown that unsoundness may be greatly improved or entirely overcome by this treatment.

The early hardening of portland cement mixtures is hastened by the addition of Cal. The strength of mortars was increased from 40 per cent to 140 per cent, and the strength of concrete from 52 per cent to 135 per cent at the age of two days by an addition of Cal equal to 5 per cent of the cement. Comparison tests, in which commercial calcium chloride was used as the accelerator, indicate that the general effect of Cal is practically the same as might be expected from the use of equivalent amounts of calcium chloride and hydrated lime.

No conclusions were drawn from very limited corrosion tests, but it is advised that caution be exercised in the use of Cal in concrete containing steel reinforcing if the concrete is to be freely exposed to the weather or excessive dampness. A. J. LAMBERT.

Tests with iron blast furnace slag. H. BURCHARTZ. *Stahl u. Eisen*, 40, 814–9 (1920).—Tests extending over a period of five years on the use of slag in reinforced concrete indicate that the slag undergoes no physical or chemical change and is entirely satisfactory for such use. *C. A.*

ACTIVITIES OF THE SOCIETY

Actions of the Board of Trustees

November 10, 1920. It was voted to approve the appointment by President Minton of the following:

George H. Brown, Chairman, Committee on Research and Development.

A. F. Greaves-Walker, Chairman, Refractories Division.

L. V. Solon Temporary Chairman, Division of Ceramic Decorative Processes.

Frederick H. Rhead, Temporary Secretary, Division of Ceramic Decorative Processes.

November 23, 1920. It was voted that, beginning January 1, 1921, the annual dues of Associate Members shall be $7.50.

Report of the Nominating Committee

To the Voting Members of the American Ceramic Society:

The Nominating Committee makes the following report on nominations for officers for the year 1921–1922:

President, F. K. Pence, American Encaustic Tiling Co., Zanesville, Ohio.

Vice-Pres., F. B. Ortman, Northwestern Terra Cotta Co., Chicago, Ill.

Treasurer, R. K. Hursh, University of Illinois, Urbana, Ill.

Trustee, R. M. Howe, Mellon Institute, Pittsburgh, Pa.

Excerpt from the Rules

"Any five Active Members may act as a self-constituted Nominating Committee and present the names of any nominees to the Secretary, provided this is done at least thirty days before the annual meeting. The names of the nominees, provided their assent has been obtained before nomination, shall be placed on the ballot without distinction as to nomination by the regular or self-constituted Nominating Committee and shall be mailed to each Active Member, not in arrears, at least twenty days before the annual meeting."

Entertainment of the Ladies at the Next Convention

To the Ladies:

Are you coming to the next annual Convention of the American Ceramic Society, February 21st to 24th. If not, why not?

The ladies are attending in increasing numbers each year and the social features of the convention are becoming of distinct importance. If you hope to attend, communicate with me at your earliest possible convenience.

Cordially yours,

(signed) Mrs. ARTHUR S. WATTS,
1764 North High St.,
Columbus, Ohio.

A Letter to the Members of the Terra Cotta Division

DEAR SIR:

Every one who attended last year's meeting of the American Ceramic Society realized the value and importance of having the Terra Cotta Division meeting separate from the main portion of the meeting. They realized that this greatly facilitated the open and free discussion of subjects of common interest to the terra cotta industry and allowed plenty of time for the reading and discussion of the nine important papers that were submitted. This also allowed the members to hear such other papers on continuous kilns, drying, glazing, etc., as were presented by the other divisions without having to waste time listening to unimportant topics.

To maintain this advantage for the Terra Cotta Division this year, it will be necessary for us to produce a good program of terra cotta papers and discussions.

I wish to urge, therefore, that the titles of such investigations as you now have under way and which you expect to have ready for the meeting, be sent to me at once so that the program can be arranged. I hope that each company will participate in some manner this year: either by submitting a paper or by leading on open discussion on some terra cotta subject. Each company certainly has some problem on which they are working, and should be glad to have the opinion of the other members on this particular subject. Send in the topic in which you are interested and it will be listed for open discussion at the meeting. This is one of the greatest benefits which are offered by our division.

Please answer this as promptly as possible.

Yours very truly,

R. L. CLARE,
Secretary Terra Cotta Division.

Meeting of the Chicago Section

The annual meeting of the Chicago Section was held at the City Club on the afternoon of November 27th. At the business session held directly after lunch, the following officers were elected for the coming year: B. S. Radcliffe, Chairman; F. L. Steinhoff, Vice-Chairman; W. W. Wilkins, Secretary-Treasurer; C. W. Parmelee, Councilor; H. E. Davis, Chairman, Program Committee; E. A. Brockman, Chairman, Membership Committee.

The following papers were read:

"Porcelain Enameling Furnace," by C. G. Armstrong. The first part of this paper was historical, dealing with the art of enameling from 1300 B. C. up to the present time. The second part dealt with enameling furnaces and especially with a new design in which carborundum refractories are employed and the regenerative principal is used.

"Spark Plug Porcelains," by W. W. Wilkins. The author stated that 75% of all failures of spark plugs is due to faulty mechanical design; 25%

of the failures can be traced to the refractory material. Tests have shown that zirconium refractories give remarkable results in spark plugs.

A third paper by R. Rodehouse described the oil-gas furnace for burning enameled ware developed by the author. The furnace has no muffle, employs no special shapes in construction and is stated to have remarkably long life.

F. L. STEINHOFF, *Secretary.*

New Members Received during November

Resident

Goodner, Ernest F., 5502 Sixteenth Ave., S. E., Seattle, Wash., Graduate Student, University of Washington.

Holmes, M. E., Ph.D., 918 G St., N. W., Washington, D. C., Manager, Chemical Dept., National Lime Association.

Luepke, Emil J., 2001 S. Kingshighway, St. Louis, Mo., Foreman, Quick Meal Stove Co.

Merica, Paul D., Ph.D., Bayonne, N. J., Supt. of Research, International Nickel Co.

Perg, Carl, 609 W. Kalamazoo Ave., Kalamazoo, Mich.

Short, Frank, 3411 Walnut St., Philadelphia, Pa., Expert in Aircraft Armament, Ordnance Dept., Frankford Arsenal.

Foreign

Solon, G. C., Royal Porcelain Works, Worcester, England Managing Director.

White, G. N., D.Sc., 7 Victoria Ave., Worcester, England, Research Chemist, Royal Porcelain Works.

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Journal of the American Ceramic Society

Volume 3

Containing the papers read at the meeting held at Philadelphia, Pa., February 23rd, 24th, and 25th, 1920, together with supplementary discussions and other matters

Homer F. Staley, Editor

This Society is not, as an organization, responsible for the statements of facts or opinions expressed in these papers and discussions

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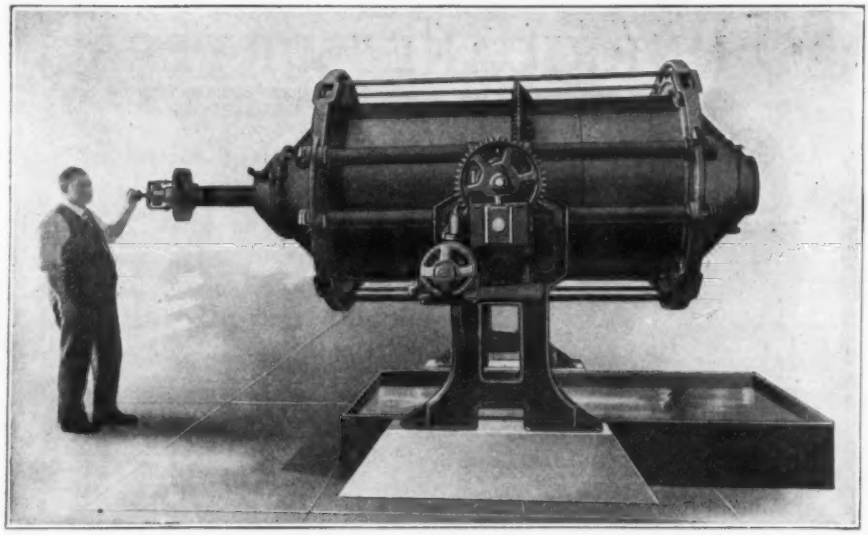

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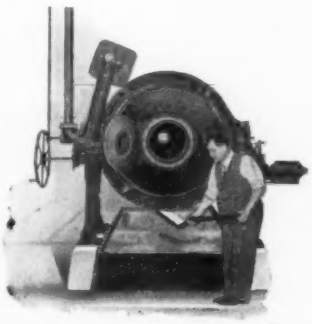

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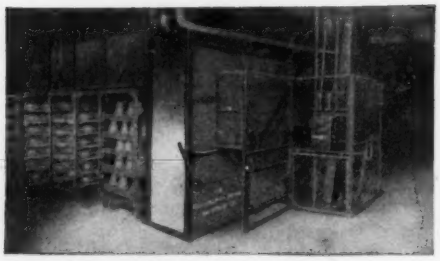

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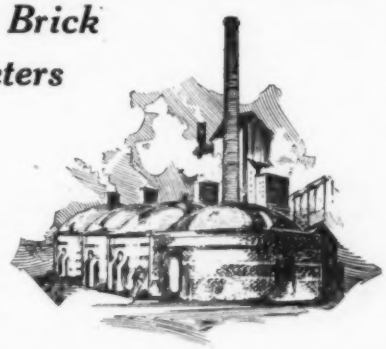

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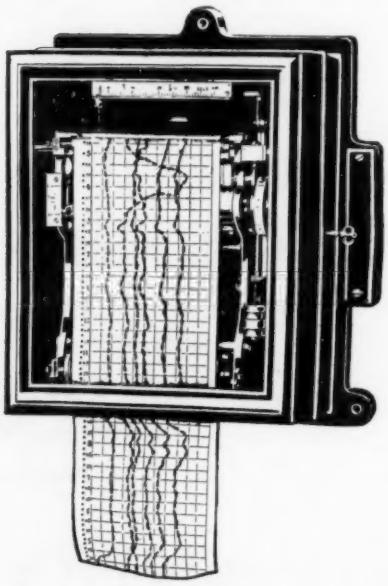

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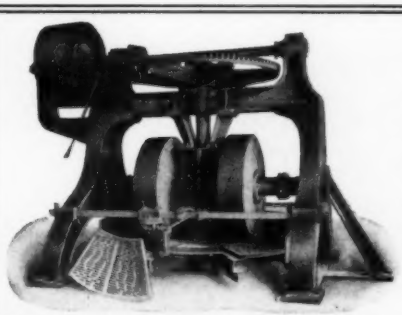

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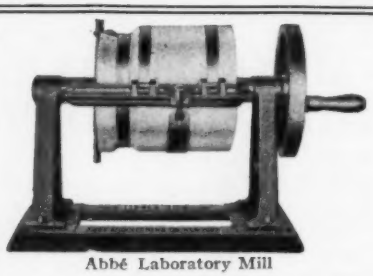

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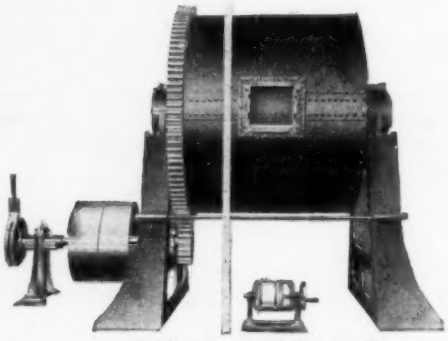

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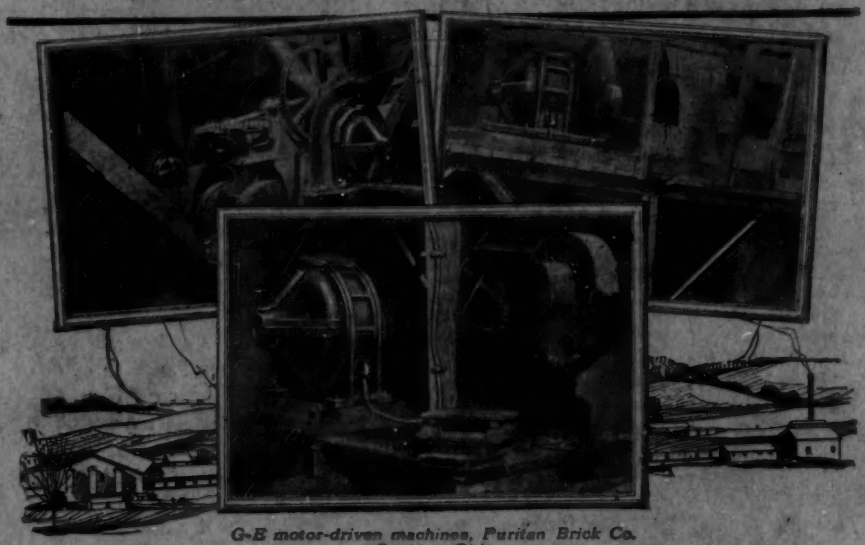
Labor shortage and high fuel costs are being met in leading brick plants by using economical and efficient electric power equipment



G-E motor-driven machines, Puritan Brick Co. Camden, Ohio

25% Increased Output and 15% Less Power Cost

were the results obtained from G-E motor drive at one brick plant.

G-E motor drive eliminates line-shaft friction, reduces maintenance cost, runs each machine at its maximum productive speed and consumes no power when machines are not running.

Brick plants all over the country have installed G-E motors. Our engineers will be pleased to give you full details of a suitable drive for your plant.

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